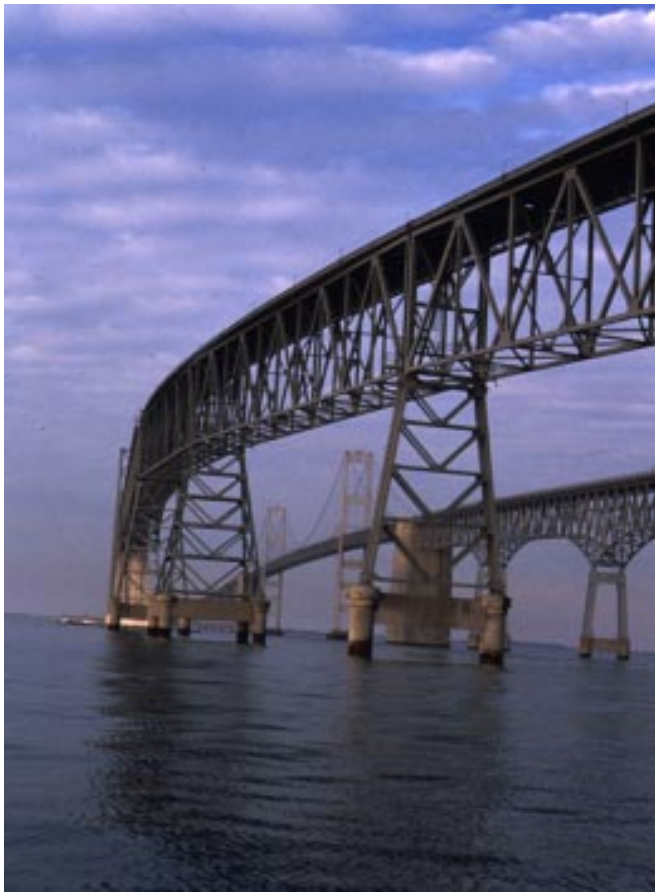
NS&T Program

National Status and Trends Program
for Marine Environmental Quality

CHESAPEAKE BAY



Center for Coastal Monitoring and Assessment
National Centers for Coastal Ocean Science
NOAA/National Ocean Service
1305 East West Hwy.
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Status and Trends of Contaminant Levels in Biota and Sediments of the CHESAPEAKE BAY

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INTRODUCTION

As part of its continuing mission to bring important results into the public arena, the NOAA National Status and Trends (NS&T) Program has prepared this summary of its findings in Chesapeake Bay.

The Chesapeake Bay is the largest drowned river estuary in North America. It is an important natural resource supporting commercial fisheries and recreational activities. The largest tributary to the Bay is the Susquehanna River, contributing more than 90% of the freshwater input north of Annapolis. Other major tributaries are the Potomac, Rappahannock, York and Patuxent rivers. The Chesapeake drainage basin includes areas in Maryland, Virginia, Pennsylvania, New York, West Virginia and the District of Columbia. It includes farmlands, woodlands, as well as heavily impacted industrial and metropolitan areas. The Bay is heavily utilized for transportation, commercial fishing and recreation.

The Chesapeake Bay has a two-layer circulation pattern. The net non-tidal flow of the denser seawater is towards the head of the Bay, close to the bottom, while the net non-tidal flow of the less dense river water is seaward, close to the surface. During periods of high river flow, the Susquehanna River dominates the upper 20 to 30 km of the Bay. Salinities, are on average, lower on the western side of the Bay (Figure 1). The mixing zone of highest water turbidity is the area where river (fresh) water and estuarine water mix, resulting in the precipitation of particulate material as salinity changes. The mixing zone of the Susquehanna River is near the entrance to Baltimore Harbor, a known pollution "hot spot" in the Bay, and a region with a high human population. Thus, it is not always possible to separate the contributions of natural estuarine processes and of pollution to the total concentrations of some

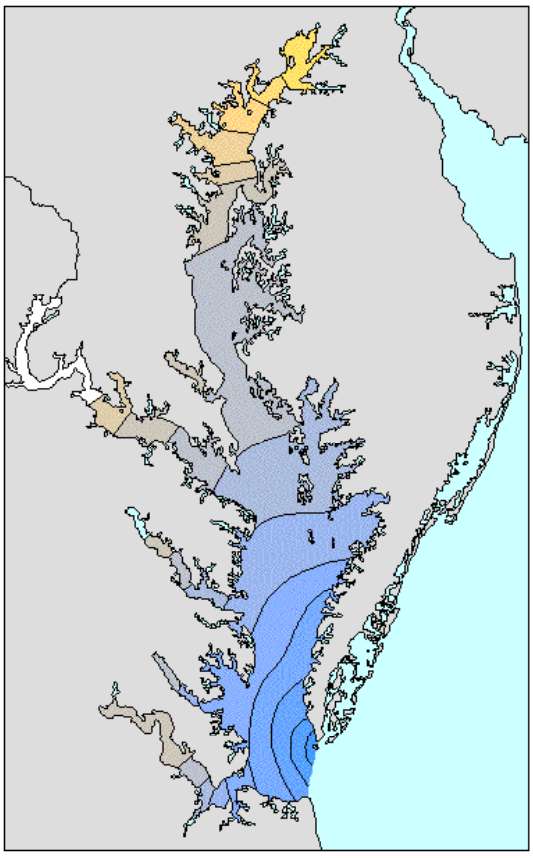


Figure 1. Typical surface salinity in Chesapeake Bay (Values range from 2-4 ppt at the north to 28-30 ppt at the mouth of the Bay.)

chemical contaminants from concentrations due to pollution.

The overall biological health of the Chesapeake Bay has shown some improvement in recent years. The population of striped bass and bottom coverage by submerged aquatic vegetation have increased, though the oyster population is decreasing. Bay wide, industrial and municipal discharges of phosphorus have been reduced while those of nitrogen continue to increase. Generally dissolved oxygen levels in the water column remain unchanged. The Bay watershed continues to experience ongoing stress due to expanding population. In 1950, the Bay watershed contained 8.4 million people. By 1990 the population had grown to 14.7 million (Chesapeake Bay Program, 1995).

NATIONAL STATUS AND TRENDS PROGRAM

Our Nation's estuaries and coastal waters receive chemical wastes from industrial, municipal, and agricultural sources. In recent decades, as industrialization has grown and diversified, complex mixtures of synthetic organic chemicals, trace elements such as mercury and lead, and nutrients such as forms of nitrogen and phosphorus, have been discharged into US coastal waters.

In addition to the industrial sources, contaminants are released to the environment in the course of our daily lives. For generations, chemicals from such non point sources as agricultural runoff, storm sewer overflow, pesticide and herbicide use, and insect spraying programs have added significantly to the total burden of coastal contaminants. Airborne transport is another significant source of contaminants to coastal ecosystems. In recent years, coastal contamination has become more of a concern as population growth in these areas continues to increase steadily. In response to these contaminant problems, an evolving national effort is underway to determine the extent and impact of contaminants on coastal and estuarine areas and to develop management strategies.

The Center for Coastal Monitoring and Assessment (CCMA), in the National Centers for Coastal Ocean Science (NCCOS) of NOAA's National Ocean Service, conducts a variety of environmental monitoring and assessment studies that are pertinent to NOAA's Environmental Stewardship mission, as outlined in its Strategic Plan: A Vision for 2005. These studies focus on three long-term goals:

- Assess the status and trends of environmental quality in relation to levels and effects of contaminants and other sources of environmental degradation in US marine, estuarine, and Great Lakes environments;

- Develop diagnostic and predictive capabilities to determine effects of contaminants and other sources of environmental degradation on coastal and marine resources and human uses of these resources;

- Develop and disseminate scientifically sound data, information, and services to support effective coastal management and decision making.

CCMA manages NOAA's NS&T Program that was initiated in 1984 to determine the status of, and to detect changes in, the environmental quality of the nation's coastal waters. This program monitors contaminant levels through the **Mussel Watch Project,** which determines concentrations of polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyl (PCB) congeners, several pesticides, butyltins, and certain toxic elements in

Oysterman's boat in Quinby, Virginia.

Oyster collection on oyster reef in Chincoteague, Virginia.

sediment and mollusk samples from the coastal waters of the U.S. (Table 1). Data are used to determine the extent and temporal trends of chemical contamination on a nationwide basis and to identify which coastal areas are at greater risk in terms of threats to environmental quality. The Mussel Watch network consists of more than 280 sites. The **Quality Assurance Project** is designed to document sampling protocols, analytical procedures, and laboratory performances of the Mussel Watch Project and is an integral part of the NS&T Program.

SURVEY METHODS

Mussel Watch Project samples are collected at regular intervals (biennially in winter for mollusks, less frequently for sediments) at about 280 sites. The sites are designed to describe national and regional distributions of contamination. Mussel Watch sites are selected to represent large coastal areas and to avoid small-scale patches of contamination, or "hot spots." Sites selected for monitoring are generally 10 to 100 km apart. Where possible, sites were selected to coincide with historical monitoring sites such as the Environmental Protection Agency's Mussel Watch sites sampled during the 1970s, and to complement sites sampled through state programs such as the California Mussel Watch Program (Lauenstein, 1996).

Mollusks (mussels or oysters) and sediments are collected at each Mussel Watch Project site. Several species of mollusks are collected: blue mussels (*Mytilus edulis*) from the US North Atlantic; blue mussels (*Mytilus* species) and California mussels (*M. californianus*) from the Pacific coast; eastern oysters (*Crassostrea virginica*) from the South Atlantic and the Gulf of Mexico; smooth-edge jewelbox (*Chama sinuosa*) from the Florida Keys; Caribbean oyster (*C. rhizophorae*) from Puerto Rico; Hawaiian oysters (*Ostrea sandvicensis*) from Hawaii; and zebra mussels (*Dreissena polymorpha* and *D. bugensis*) from the Great Lakes. Eastern oysters are collected in the Chesapeake Bay. Coastal and estuarine mollusks are dredged or picked from intertidal to shallow subtidal zones, brushed clean, packed in dry ice, and shipped to the analytical laboratory. Sediments are collected using a grab sampler and the top two centimeters are removed for analysis. The mollusk and sediment samples are usually shipped to the laboratory within a day of collection.

Once in the laboratory, molluscan samples are composited. Each mussel composite contains 30 individuals and each oyster composite contains 20 individuals. The molluscan composite samples and sediment samples are analyzed for organic and metal contaminants. The sampling and analytical protocols are described in detail in Lauenstein and Cantillo (1993 and 1998).

Data are also available from the NS&T **Benthic Surveillance Project** that analyzed contaminant levels and effects in sediment and fish from over 100 sites in 1984 through 1992. The Project is currently inactive. The Project sediment data are combined with those of the Mussel Watch Project data in this report.

The NS&T Mussel Watch and Benthic Surveillance sites in Chesapeake Bay and nearby coastal areas are shown in Figure 2. The site names, acronyms, latitudes and longitudes, years of data available and population within 20 km of the site are listed in Table 2.

The average concentrations of major and trace elements and of categories of organic compounds are shown graphically in the Appendices. Appendix II provides graphical representations of trace element and organic concentrations in oysters through time at selected sites.

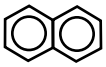
TABLE 1

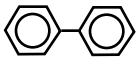
Organic contaminants and major and trace elements determined as part of the NS&T Program.

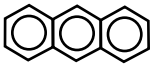
Polycyclic aromatic hydrocarbons

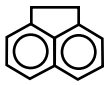
Low molecular weight PAHs
(2- and 3-ring structures)

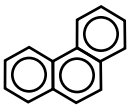
1-Methylnaphthalene
1-Methylphenanthrene
2-Methylnaphthalene
2,6-Dimethylnaphthalene
1,6,7-Trimethylnaphthalene
Acenaphthene
Acenaphthylene
Anthracene
Biphenyl
Fluorene
Naphthalene
Phenanthrene


Naphthalene
91-20-3

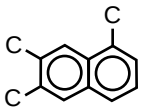

Biphenyl
92-52-4

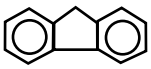

Anthracene
120-12-7

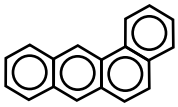

Acenaphthene
83-32-9

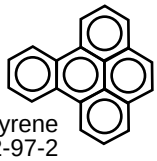

Phenanthrene
85-01-8

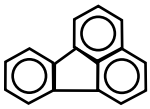

Acenaphthylene
208-96-8

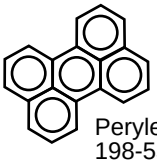

1,6,7-Trimethylnaphthalene
2245-38-7

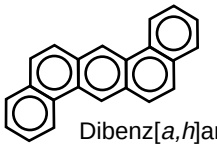

Fluorene
86-73-7

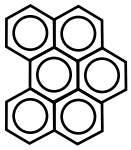

Benz[*a*]anthracene
56-55-3


Benzo[*e*]pyrene
192-97-2


Fluoranthene
206-44-0


Perylene
198-55-0


Dibenz[*a,h*]anthracene
53-70-3

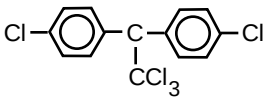

Benzo[*ghi*]perylene
191-24-2

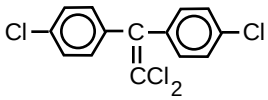
High molecular weight PAHs
(4-, 5-, and 6-rings)

Benz[*a*]anthracene
Benzo[*a*]pyrene
Benzo[*b*]fluoranthene
Benzo[*e*]pyrene
Benzo[*ghi*]perylene
Benzo[*k*]fluoranthene
Chrysene
Dibenz[*a,h*]anthracene
Fluoranthene
Indeno[1,2,3-*cd*]pyrene
Perylene
Pyrene

Chlorinated pesticides

2,4'-DDD
4,4'-DDD
2,4'-DDE
4,4'-DDE
2,4'-DDT
4,4'-DDT


4,4-DDD
72-54-8


4,4-DDE
72-55-9

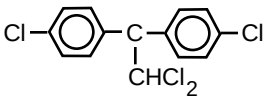
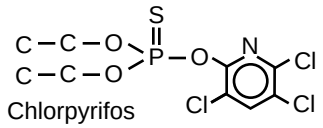

4,4-DDT
50-29-3

TABLE 1 (cont.)

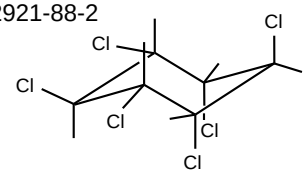
Organic contaminants, and major and trace elements determined as part of the NS&T Program.

(Number in parenthesis below chemical structure is the Chemical Abstracts Service registry number.)

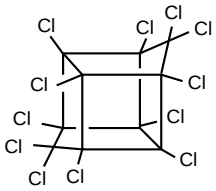
Aldrin
Chlorpyrifos
cis-Chlordane
Dieldrin
Endosulfan-I
Endosulfan-II
delta-Hexachlorohexane
gamma-Hexachlorohexane
Heptachlor
Heptachlor epoxide
Hexachlorobenzene
alpha-Hexachlorohexane
beta-Hexachlorohexane
Mirex
cis-Nonachlor
trans-Nonachlor
Oxychlordane



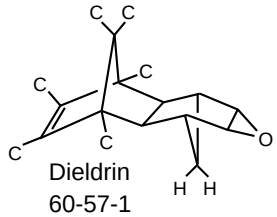
Chlorpyrifos
2921-88-2



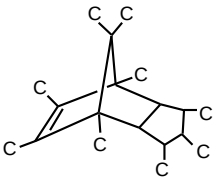
gamma-Hexachlorohexane
58-89-9



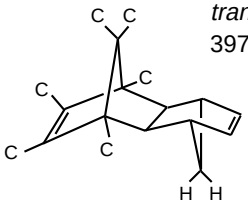
Mirex
2385-85-5



Dieldrin
60-57-1



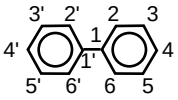
trans-Nonachlor
39765-80-5



Aldrin
309-00-2

Polychlorinated biphenyl congeners (IUPAC numbering system)

PCB 8, PCB 18, PCB 28, PCB 44, PCB 52, PCB 66, PCB 101, PCB 105, PCB 118, PCB 128, PCB 138, PCB 153, PCB 170, PCB 180, PCB 187, PCB 195, PCB 206, PCB 209

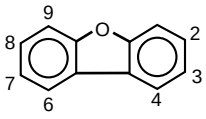


PCB parent structure

Planar PCBs (PCB 77, PCB 126, PCB 169)

Chlorinated dibenzofurans

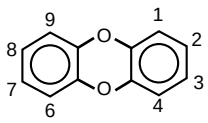
2,3,7,8-Tetrachlorodibenzofuran
1,2,3,7,8-Pentachlorodibenzofuran
2,3,4,7,8-Pentachlorodibenzofuran
1,2,3,4,7,8-Hexachlorodibenzofuran
1,2,3,6,7,8-Hexachlorodibenzofuran
2,3,4,6,7,8-Hexachlorodibenzofuran
1,2,3,7,8,9-Hexachlorodibenzofuran
1,2,3,4,6,7,8-Heptachlorodibenzofuran
1,2,3,4,7,8,9-Heptachlorodibenzofuran
Octachlorodibenzofuran



Dibenzofuran parent

Chlorinated dioxins

2,3,7,8-Tetrachlorodibenzo-*p*-dioxin
1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin
1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin
1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin
1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin
1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin
Octachlorodibenzo-*p*-dioxin



Dioxin parent structure

TABLE 1 (cont.)

Organic contaminants, and major and trace elements determined as part of the NS&T Program.

(Number in parenthesis below chemical structure is the Chemical Abstracts Service registry number.)

Major and trace elements

Al	-	aluminum	Cu	-	copper	Ag	-	silver
Si	-	silicon	Zn	-	zinc	Cd	-	cadmium
Cr	-	chromium	As	-	arsenic	Hg	-	mercury
Mn	-	manganese	Se	-	selenium	Tl	-	thalium
Fe	-	iron	Sn	-	tin	Pb	-	lead
Ni	-	nickel	Sb	-	antimony			

Organotins

Monobutyltin^{3+}, dibutyltin^{2+}, tributyltin^{+}, tetrabutyltin

RESULTS AND DISCUSSION

Status

Oysters

Oysters and mussels are not equal in their ability to concentrate trace elements (O'Connor, 1993). The trace elements Ag, Cu, and Zn are concentrated in the oyster *C. virginica* relative to the mussel *M. edulis.* Conversely, Cr and Pb are more than three times higher in the mussel than in the oyster. Therefore, only the NS&T nationwide oyster data were used to compare to the Ag, Cu and Zn Chesapeake Bay oyster data. The differences in bioaccumulation between oysters and mussels for Cr, Ni, As, Se, Cd, Hg, Pb and the organic analytes are not sufficiently great as to prevent the combination of the data from the two bivalves.

The Chesapeake Bay data were compared to the nationwide NS&T median and 85th percentile values. Concentrations above the 85th percentiles are the highest 15% of the data set and are used as a measure of "high" concentrations. Percentiles are robust with regard to both outliers and concentrations below the detection limit. The NS&T medians and 85th percentiles are listed in Table 3.

The mean oyster concentrations of many analytes and trace organic chemical categories are higher than the NS&T 85th percentile in the northern part of the Bay. High values were also found in the southern area of the Bay near Hampton Roads and the James River (i.e., Cr, Ni, Cu, Zn, ∑DDTs, ∑PCBs and others). Lower values were generally found in the middle section of the Bay. Some high levels were also found at stations located in tributaries such as the sites at Mattox Creek and Ross Rock.

The higher values found in the northern and southern parts of the Bay may reflect human population levels. The highest population densities along the Bay shorelines are found in the north (city of Baltimore) and in the south (Norfolk) (Figure 3). Nationwide, using all data, there is a strong statistical correlation between human population density and chemical concentrations in oysters and mussels for chlordane, ∑DDTs, ∑PCBs, ∑PAHs, ∑BTs and Pb.

The higher trace element values found in the northern area may also be, in part, the result of natural estuarine processes resulting from the mixing of river water with estuarine water. The mixing zone of the Susquehanna river water with the higher salinity estuarine water is

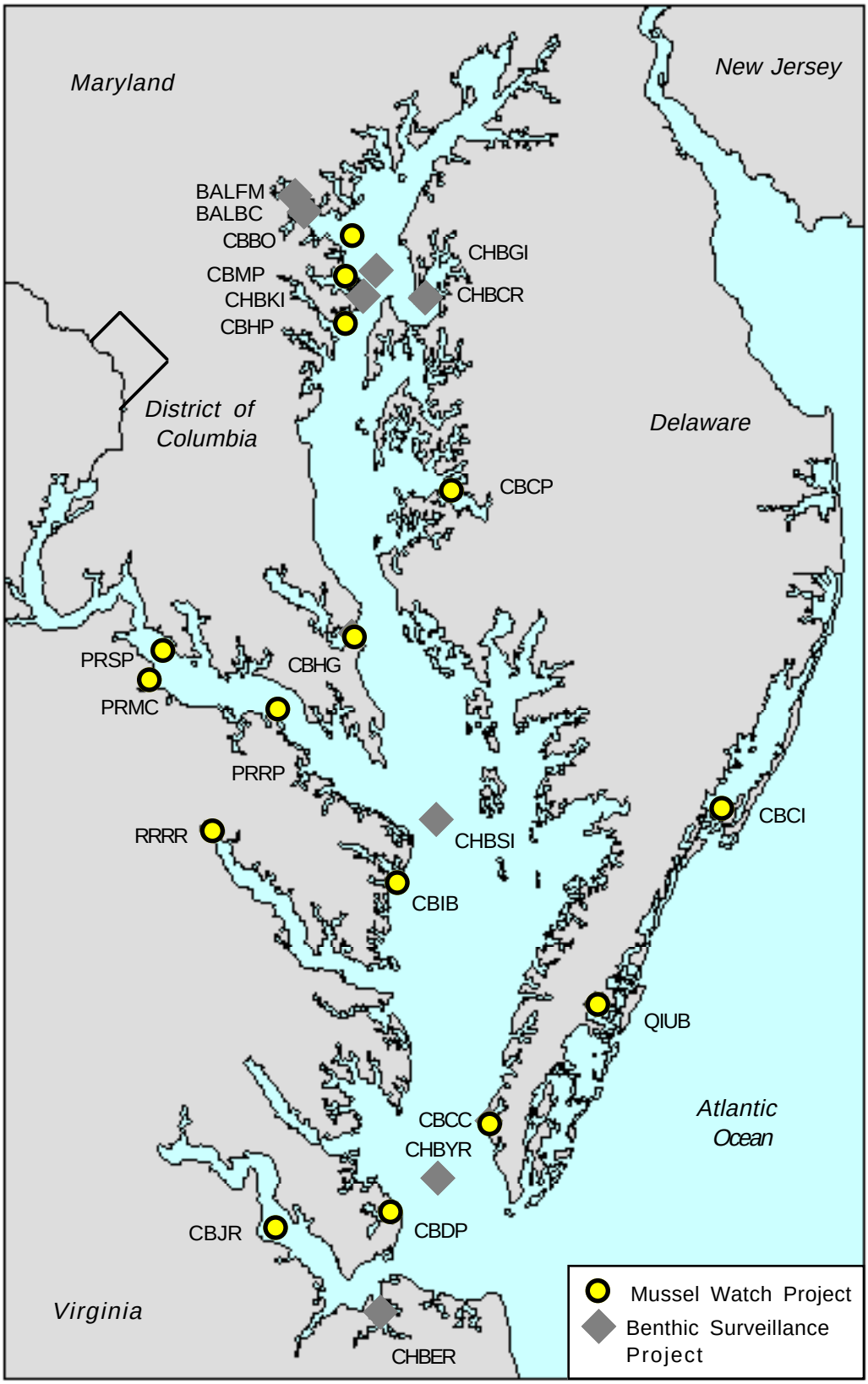


Figure 2. NS&T Mussel Watch and Benthic Surveillance sampling sites in Chesapeake Bay and nearby coastal areas.

TABLE 2

NS&T sampling sites in Chesapeake Bay and nearby coastal areas.

Site	Site code	Latitude (N)	Longitude (W)	Years of tissue data*	Population$^{\Delta}$ (20 km of site)
Mussel Watch Project					
Chincoteague Inlet	CBCI	37° 56.31'	75° 22.55'	9	11211
Upshur Bay	QIUB	37° 31.50'	75° 42.83'	9	14944
Cape Charles	CBCC	37° 17.07'	76° 00.92'	9	7298
Choptank River	CBCP	38° 36.44'	76° 07.20'	6	36019
Bodkin Pt.	CBBO	39° 09.44'	76° 24.29'	4	317119
Mountain Pt. Bar	CBMP	39° 04.32'	76° 24.76'	9	237780
Hackett Pt. Bar	CBHP	38° 58.17'	76° 24.88'	9	181152
Hog Pt.	CBHG	38° 18.74'	76° 23.87'	8	55272
Swan Pt.	PRSP	38° 16.90'	76° 56.02'	3	28035
Mattox Creek	PRMC	38° 13.40'	76° 57.69'	3	23827
Ragged Pt.	PRRP	38° 09.30'	76° 36.05'	6	47769
Ingram Bay	CBIB	37° 47.63'	76° 17.06'	2	12862
Ross Rock	RRRR	37° 54.12'	76° 47.27'	6	16026
Dandy Pt.	CBDP	37° 05.90'	76° 17.69'	9	324484
James River	CBJR	37° 03.92'	76° 37.93'	4	229742
Benthic Surveillance Project					
Ft. McHenry Channel	BALFM	39° 14.7'	76° 33.8'		1410684
Gibson Island	CHBGI	39° 05.0'	76° 20.0'		139822
Kent Island	CHBKI	39° 01.4'	76° 22.1'		-
Smith Island	CHBSI	37° 55.0'	76° 10.0'		4878
York River	CHBYR	37° 10.0'	76° 10.0'		33826
Elizabeth River	CHBER	36° 50.8'	76° 18.0'		795765

* Years of tissue data available through 1995.

$^{\Delta}$ 1990 Census.

TABLE 3

NS&T Mussel Watch Data medians and 85th percentile values (1986 - 1997)

(Medians and percentiles were determined using the average at each site across all sampled years. Element data in µg/g dry wt. unless noted, and organic data in ng/g.).

Oyster data only

	Cr	Cu	Zn	Ag	Pb
n	128	128	128	128	128
Median	0.69	140	2200	2.3	0.51
85th percentile	1.1	290	4600	5.0	0.82

Mussel and oyster data

	Ni	As	Se	Cd	Hg
n	281	281	281	281	280
Median	1.9	9.2	2.8	2.8	0.10
85th percentile	2.1	16	3.9	5.9	0.21

	∑DDTs	∑PCBs	∑PAHs	∑Cdane	∑Dieldrin
n	280	280	268	280	280
Median	33	100	300	10	5.1
85th percentile	140	450	1200	32	15

	Mirex	Hexachloro-benzene	Lindane	Endrin	∑BTs
n	280	280	280	45	250
Median	0.24	0.23	1.2	0.38	54
85th percentile	1.2	1.1	2.8	2.3	200

Sediment data (Calculated using Mussel Watch Program sediment data only.)

	Al (%)	Si (%)	Cr	Mn	Fe (%)
n	223	178	222	199	223
Median	4.8	3.0	54	370	2.1
85th percentile	2.4	36	120	740	3.7

	Ni	Cu	Zn	As	Se
n	223	223	223	223	207
Median	17	14	67	6.9	0.38
85th percentile	36	47	130	12	0.74

	Ag	Cd	Sn	Sb	Hg
n	223	223	223	178	223
Median	0.11	0.19	1.3	0.47	0.057
85th percentile	0.59	0.56	3.1	1.8	0.22

TABLE 3 (cont.)

	Tl	Pb	TOC (%)	∑DDTs	∑PCBs
n	145	223	220	224	224
Median	0.073	18	1.0	2.9	15
85th percentile	0.56	40	2.4	18	80

	∑PAHs	∑Cdane	∑Dieldrin	Mirex
n	224	224	224	224
Median	380	0.51	0.30	0.002
85th percentile	2300	3.1	1.9	0.36

	Hexachloro-benzene	Lindane
n	223	224
Median	0.14	0.04
85th percentile	0.92	0.47

∑DDTs: The sum of concentrations of DDTs and its metabolites, DDEs and DDDs.
∑PCBs: The sum of the concentrations of homologs, which is approximately twice the sum of the 18 congeners.
∑PAHs: The sum of concentrations of the 18 PAH compounds.
∑Cdane: The sum of *cis*-chlordane, *trans*-nonachlor, heptachlor and heptachlorepoxide.
∑Dieldrin: The sum of dieldrin and aldrin.
∑BT: The sum of the concentrations of tributyltin and its breakdown products dibutyltin and monobutyltin (as ng Sn/g dry wt.).
n: Number of data points (roughly equivalent to the number of sampling sites).

found near the entrance to Baltimore Harbor thus making differentiation between natural and anthropogenic inputs to the area difficult.

Mean Ni concentrations in oysters were found to be higher than the NS&T 85th percentile in all the Bay and adjacent area samples and this may reflect the mineral composition of the rocks and minerals in the region. Chromium was mined commercially in the Chesapeake Bay basin during colonial times, and chromium and nickel often occur together (Helz, personal communication, 1998).

The distributions of As and Hg do not show a correlation with human population. The concentrations of these elements found at sites with a strong marine influence are higher than those further away from the open coast. The As and Hg levels do not exceed the NS&T 85th percentile concentrations. Lead levels were higher at the James River Dandy Point sampling site than elsewhere in the Bay but were below the 85th percentile level. Selenium levels were higher than the 85th percentile at all the sites except Upshur Bay and Cape Charles.

Most of the organic contaminants measured by the NS&T Program are man-made and their presence in the environment is a direct consequence of introduction of these chemicals by human activities. Polycyclic aromatic hydrocarbons (PAHs) are the exception since there are known natural sources of these chemicals. ∑PCBs were above the 85th percentile levels at the sites in the northern Bay, the Potomac, Ingram Bay, Dandy Point and Cape Charles. PCB production was banned in the US in the 1970s. The levels of ∑DDTs in oysters were below the 85th percentile at all the sites, and the highest levels were found at Cape Charles. Alpha-chlordane, *trans*-nonachlor, heptachlor and heptachlor epoxide have a common source and similar chemical structures (Table 1). Aldrin degrades into dieldrin.

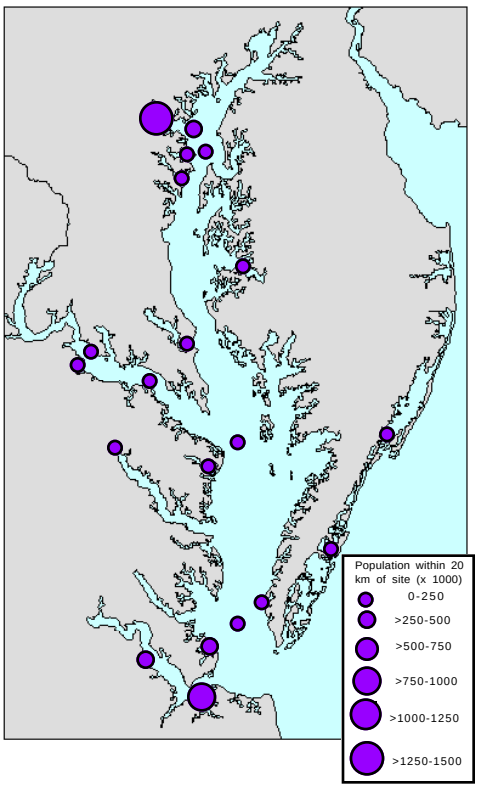


Figure 3. Population within 20 km of the NS&T sampling sites.

Thus these compounds follow similar pathways in the environment. The sums of the concentrations of these pesticides in oysters were above the 85th percentile at the sites in the northern Bay and at Ingram Bay.

Dieldrin and aldrin also have similar structures. The sums of the concentrations of these pesticides in oysters were above the 85th percentile at one site in the northern Bay and at Hog Pt. Levels of hexachlorobenzene were above the 85th percentile at two sites in the northern Bay and at Hog Pt. Lindane (gamma-hexachlorohexane) was above the 85th percentile at two of the sites in the northern Bay. Mirex was also high at one of the northern sites, at Ingram Bay and at Dandy Pt.

Tributyltin, as it leaches from antifouling paints, inhibits the attachment of marine organisms to surfaces coated with the paint. Vessels and boats coated with tributyltin antifouling paints and vessel repair facilities are major sources for the release of tributyltins into the marine environment. The major breakdown products of tributyltins are mono- and dibutyltin. Tributyltin was found to be the dominant chemical species of the butyltins. High levels of ∑BTs in oysters or mussels are indicators of heavy boating activity. Maximum ∑BTs occurs in marine and harbor areas. The highest levels of ∑BTs, above the 85% percentile, were found at Dandy Pt. and the James River.

Sediment

As river water mixes with estuarine or marine water at the mixing zone in the upper bay, large amounts of material are usually deposited into the sediment. The deposited material can be particles that were carried by the river from sources upstream or can be particles or coatings on particles formed as the result of changes in the chemistry of the water. Estuaries are known metal depositories and little of the deposited material escapes to coastal waters (Turekian, 1977). The Susquehanna River contributes a large quantity of fine-grained sediment, and continental shelf sources supply a vast quantity of sand and suspended sediment. (Hobbs *et al.*, 1992). Biggs and Howell (1984) estimated that 98% of the suspended material in the Bay becomes trapped and does not reach the Bay mouth. The largest concentrations of trace elements and organic contaminants in the Bay are found in Baltimore Harbor. The Harbor, however, contributes little to the sediment of the upper Bay and there is minimal material transport south from the northern section of the Bay (Sinex and Wright, 1988).

Clay deposition occurs between the Rappahannock and Potomac Rivers. The central basin of the Bay between the Pocomoke Sound and the York River has the highest silt deposition. The area with the largest sand deposition occurs at the mouth of the Bay. (Hobbs *et al.*, 1992).

Nickel levels in sediment at all sites are higher than the NS&T 85th percentile and this reflects the mineralogy of the area. Copper, Zn, As levels were high in the upper Bay as well as at the Elizabeth River site. Zinc was enriched in surface sediments of the northern two thirds of the Bay by a factor of 2-3 over shales (Helz *et al.*, 1985a and 1985b). Arsenic levels were

also elevated at the Ragged Pt. and Ingram Bay sites. The distribution of As in sediments does not reflect the distribution of As in oysters. High levels of Ag and Cd were found at Mattox Creek, Ragged Pt. and the Elizabeth River. Mercury and Pb levels were high at the Elizabeth River site. Selenium levels were higher than the NS&T 85th percentile levels at many sites.

Zinc was enriched in surface sediments of the northern two thirds of the Bay by a factor of 2-3 over shales. The excess Zn to organic carbon ratio decreases systematically southward, unlike the ^{210}Pb to organic carbon ratio, indicating a regional decline in atmospheric Zn deposition. (Helz *et al.*, 1985a and 1985b).

A comparison was made between the results of analyses of sediment cores collected in 1978 (Cantillo, 1983) and the NS&T Program sediment values. Only the results of the analyses of the top 2 cm of the cores were used. Comparison of the results at sites in the northern, middle, and southern Bay showed no significant differences over the 10-year time span between the two sample sets. The elemental composition differences observed reflect variations in sand content of the samples. This is an indication that usually sediment composition does not change significantly from year to year.

The levels of ∑PAHs found in the northern Bay (12,000 ng/g) and at the Elizabeth River site (14,000 ng/g) are well above the NS&T 85th percentile level (2,300 ng/g). Elsewhere, levels of PCBs are below the 85th percentile. The levels of ∑DDTs and chlordane pesticides, were high at the northern sites and at the Elizabeth River. Chlordane pesticides were also high at Mattox Creek. Dieldrin and aldrin were high at Choptank River, Mattox Creek and the northern Bay sites. Hexachlorobenzene was also high at the Choptank River and at Swan Pt. Lindane was high in the northern sites, Smith Island, York River, Dandy Pt. and James River sites. Mirex was high at the northern stations.

Significant risk to aquatic life from contaminated sediments has been found in sediments from Baltimore Harbor, the Elizabeth River and the Anacostia River, and less so from the upper reaches of some of the northern rivers such as the Susquehanna (Chesapeake Bay Program, 1995).

There were very high levels of many of the NS&T analytes at the Ft. McHenry Channel site (i.e., Cr, Ni, Cu, Zn, As, Se, Ag, Cd, Hg, Pb, ∑PAHs, ∑PCBs, ∑DDTs, chlordane pesticides). This site is within Baltimore Harbor and does not generally reflect levels of these analytes in the main stem of the Bay.

Trends

Contamination trends at the NS&T sites around the US from 1986 through 1995 have been identified by statistically comparing annually measured concentrations in mollusk samples from each of 186 sites that were sampled for at least six years. Calculations for each chemical at each sampling site showed increasing, decreasing, or no trends over time. The most common observation was no trend, but when trends were found decreases greatly outnumbered increases. Contamination is decreasing for chemicals whose use has been banned, such as chlordane, DDT, and dieldrin, or severely curtailed, such as tributyltin and cadmium. For other chemicals there is no evidence, on a national scale, for either increasing or decreasing trends (O'Connor, 1996). Table 3 shows the numbers of sites with Increasing (I), Decreasing (D), or No Trends (NT) in concentrations of each chemical.

The numbers in Table 3 are the result of a statistical test that will identify random sequences as real trends about 5% of the time. Since 186 sites were examined for each chemical, this means that about 10 of the trends per chemical could be due to random variations. That is why we have not given much weight to the relatively few trends that appear for most of the trace elements and for PAHs.

Statistical correlations were also developed for the median (middle) value of chemical concentrations among all sites sampled in each year from 1986 to 1995. These plots of annual medians show, at this national level of aggregation, decreasing trends for cadmium, copper in mussels, zinc in mussels, all the chlorinated organics, ∑PAH, and ∑BT. The copper, zinc, and ∑PAH decreases were not evident in the site-by-site results.

TABLE 4

National trends in chemical concentrations measured as part of the NS&T Mussel Watch Project and trends for the seven Chesapeake Bay area sites (CBMP, CBHP,CHHG, CHDP, CBCC, CBCI, QIUB) for which data exist for the years 1986-1993.

	Trend				Trend		
Aggregated chemicals*	I	D	NT	Element	I	D	NT
Cdane	1	81 (6)	104	As	11 (1)	11 (2)	164
DDT	1	38 (3)	147	Cd	3	28 (1)	155
Dield	1	32 (4)	153	Cu	7	14	165
PCB	1	37 (4)	148	Hg	7	9	170
PAH	3 (1)	3 (1)	180	Ni	6	8	172
BT	0	18 (1)	168	Pb	14 (1)	9	163
				Se	8	9	169
				Zn	7	9	170

I - Increasing; D - Decreasing, NT - No trend.
* Individual organic compound concentrations have usually been aggregated into these groups:
DDTs: The sum of concentrations of DDTs and its metabolites, DDEs and DDDs.
PCBs: The sum of the concentrations of homologs, which is approximately twice the sum of the 18 congeners.
PAHs: The sum of concentrations of the 18 PAH compounds.
Cdane: The sum of *cis*-chlordane, *trans*-nonachlor, heptachlor and heptachlorepoxide.
Dieldrin: The sum of dieldrin and aldrin.
BT: The sum of the concentrations of tributyltin and its breakdown products dibutyltin and monobutyltin (as ng Sn/g dry wt.).

Decreasing trends are not unexpected. All the monitored chlorinated hydrocarbons have been banned for use in the United States and tributyltin has been banned as a biocide on small boats. Annual consumption of cadmium in the U.S. decreased over the period of 1986 through 1995.

The number of increasing and decreasing contaminant trends in the Chesapeake Bay area are noted in Table 4. Main stem contaminant concentrations either decreased or showed no contaminant change with time. The Quinby Inlet site on the Atlantic side of the Delmarva Peninsula was the only site where increasing contaminant concentrations were noted.

CONCLUSIONS

In general, environmental conditions in the Chesapeake Bay, as determined by using results of the NS&T Program, are good and in some instances improving. Areas with high concentrations of the NS&T analytes were found, especially in Baltimore Harbor and the Hampton Roads areas.

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NS&T DATA AND INFORMATION PRODUCTS

Data and information resulting from CCMA activities are made available to users and the scientific community at large in different formats and media.

NOAA Technical Memoranda provide detailed accounts of methods, data summaries, and results of various NS&T Program projects and related activities, such as sediment toxicity surveys, analytical methods, and sediment quality assessments.

Digitized data and program information about the NS&T program are available via electronic mail. Presently, data from the Mussel Watch project (1984-1994) and the Benthic Surveillance project (1984-1992) can be retrieved by downloading from the NCCOS Information Service which can be accessed at (http://seaserver.nos.noaa.gov). New data sets are added to the service as they are digitized and checked for accuracy. The data sets can also be requested from the CCMA office.

Scientific publications containing the results of CCMA projects are published as research papers in journals, books, and proceedings of professional conferences. The publications are authored by CCMA staff, contractors, and collaborators in different agencies. A cumulative list of these publications is issued periodically.

For further information on the NS&T Program or to obtain a list of available publications, write:

Oyster shells.

National Status and Trends Program
NOAA/NOS/NCCOS/CCMA
1305 East/West Highway
Silver Spring, MD 20910

Phone: 301 713 3028
Fax: 301 713 4388

APPENDICES

Appendix I
Sediment data

Appendix II
Trace element and organic trends in oysters

Trends at Mountain Point Bar, Hackett Point Bay, Hog Point and Dandy Point

Trends at Dandy Point and Cape Charles

Appendix I

NS&T sediment data for the Chesapeake Bay and nearby areas

Chromium in sediment

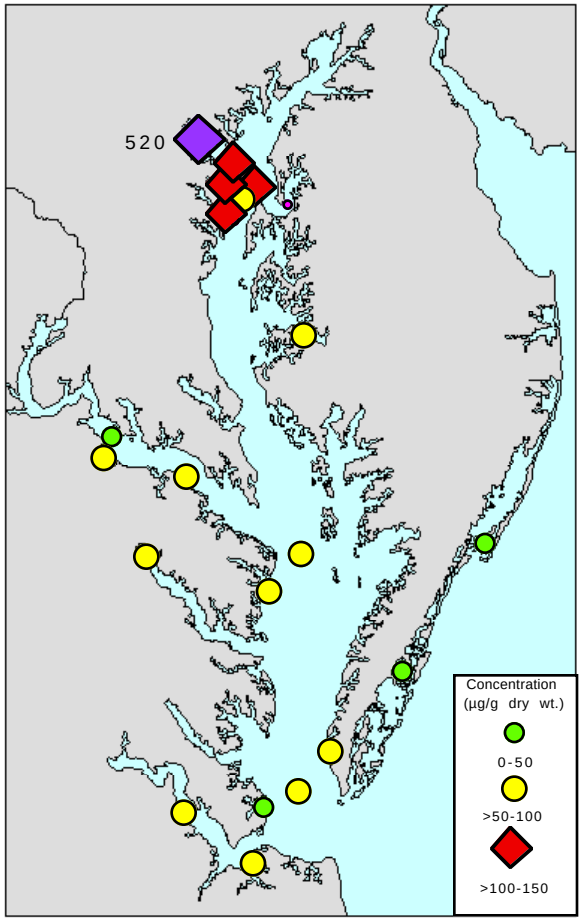


Figure I.1. Chromium in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T nationwide 85th percentile (µg/g dry wt.).

Manganese in sediment

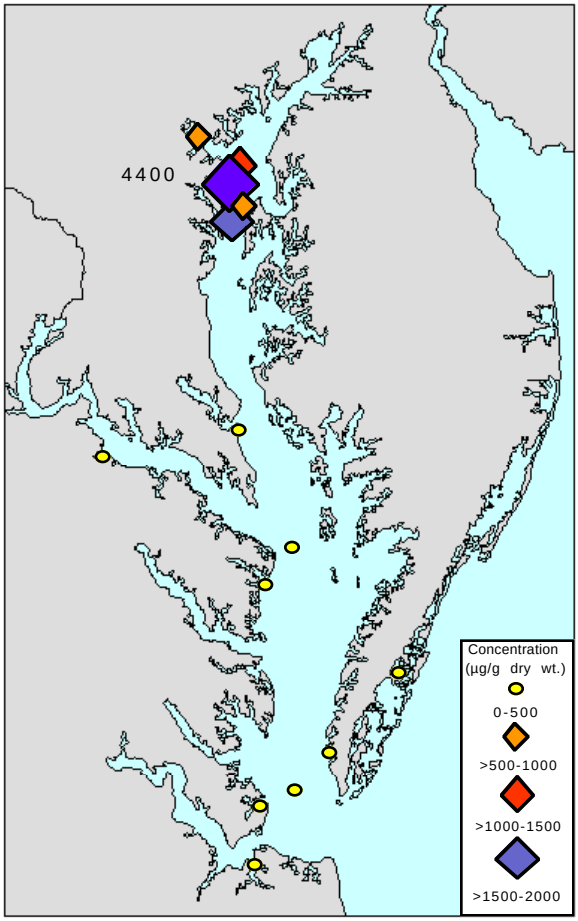


Figure I.2. Manganese in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T nationwide 85th percentile (µg/g dry wt.).

Nickel in sediment

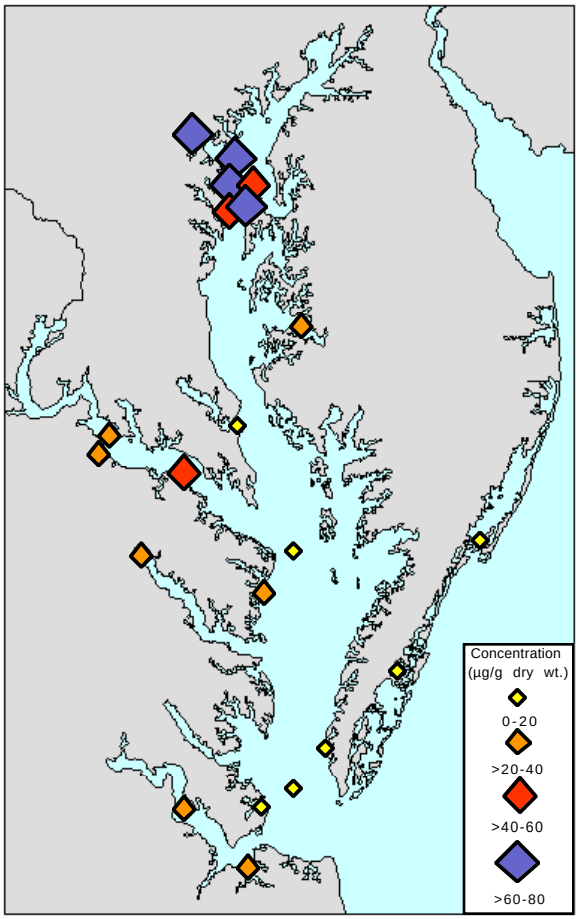


Figure I.3. Nickel in sediment. Average of data from 1986 to 1995. Concentrations were above the NS&T nationwide 85th percentile (µg/g dry wt.).

Copper in sediment

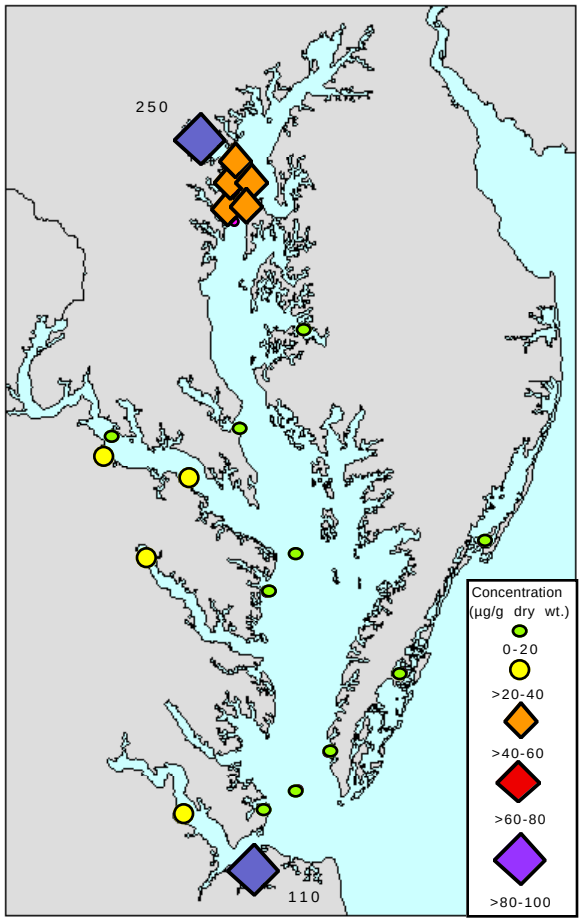


Figure I.4. Copper in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T nationwide 85th percentile (µg/g dry wt.).

Sampling using oyster tongs.

Zinc in sediment

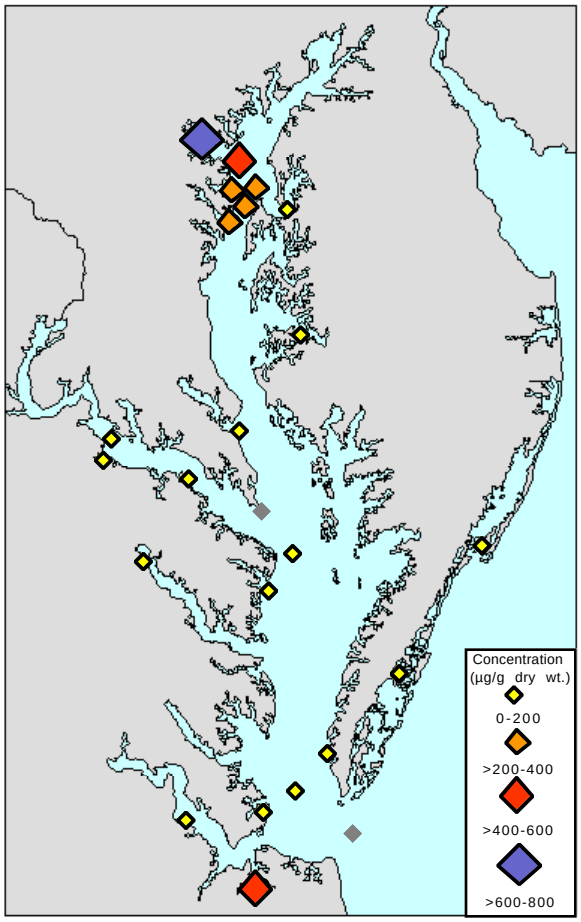


Figure I.5. Zinc in sediment. Average of data from 1986 to 1995. Concentrations were above the NS&T nationwide 85th percentile (µg/g dry wt.).

Arsenic in sediment

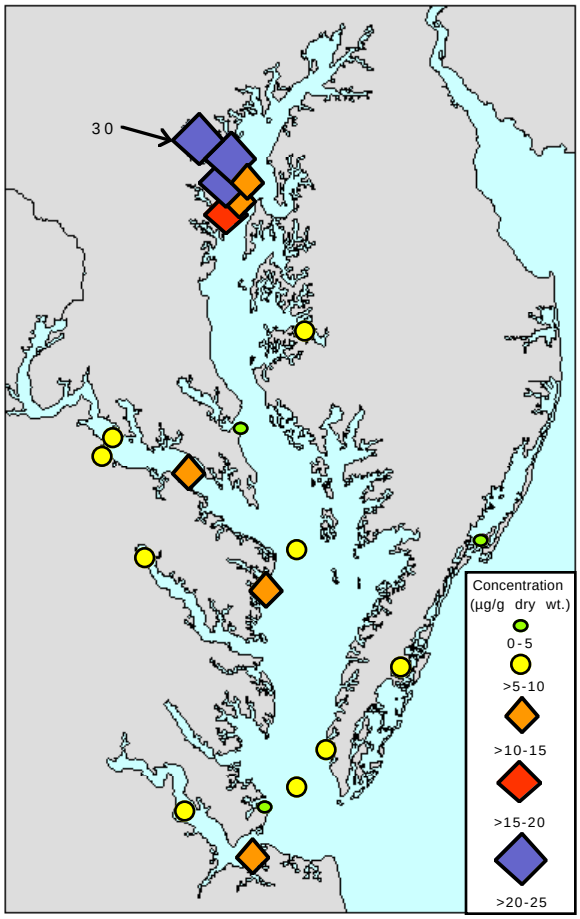


Figure I.6. Arsenic in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T nationwide 85th percentile (µg/g dry wt.).

Selenium in sediment

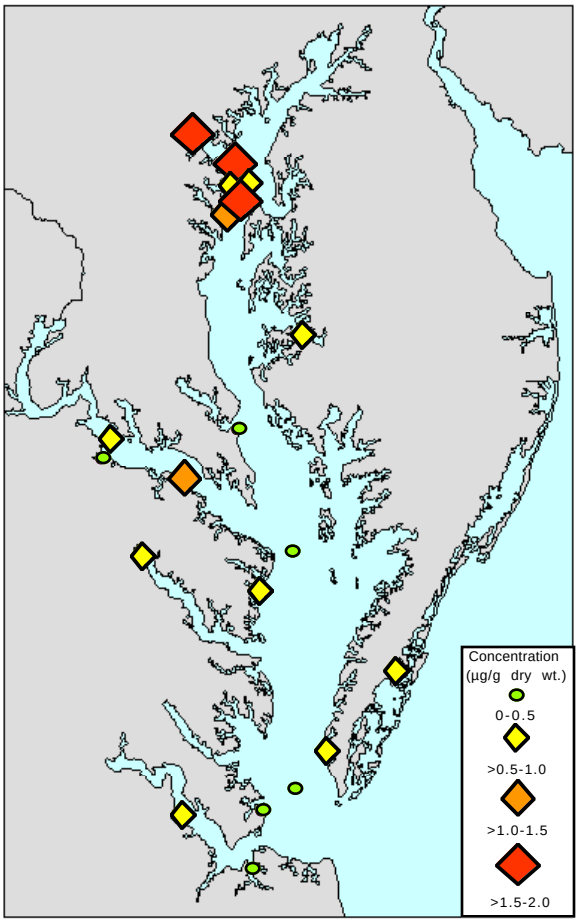


Figure I.7. Selenium in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T nationwide 85th percentile (µg/g dry wt.).

Silver in sediment

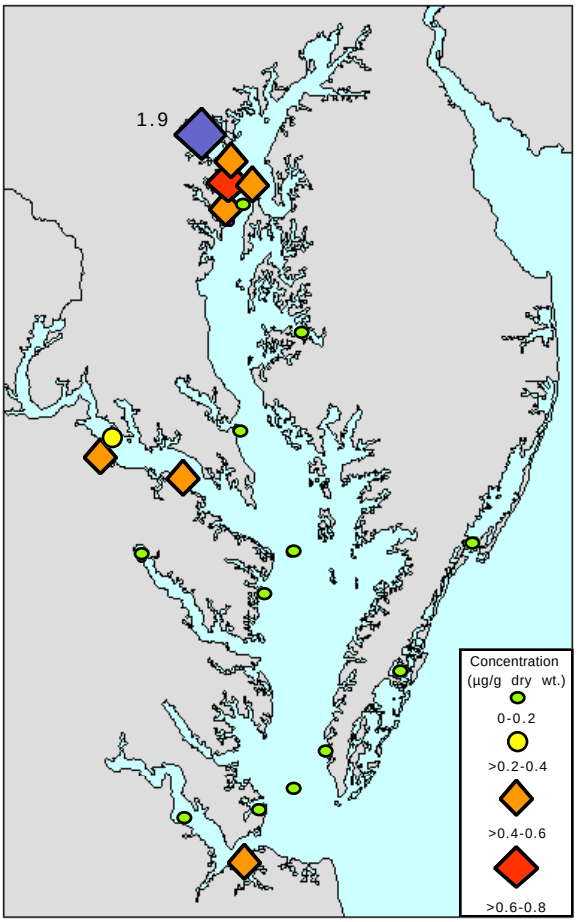
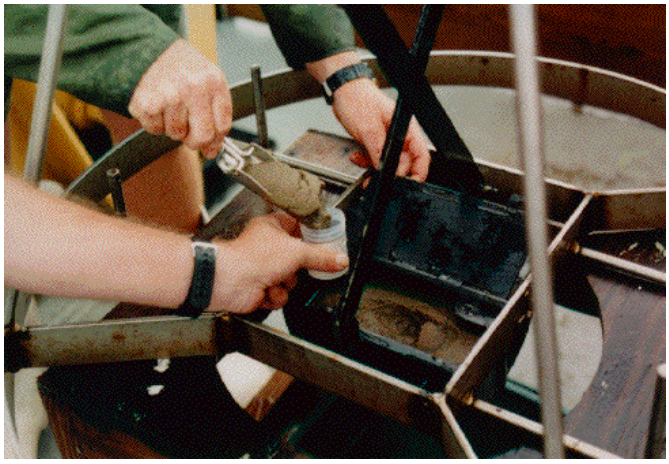


Figure I.8. Silver in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T nationwide 85th percentile (µg/g dry wt.).



Sediment sampling.

Cadmium in sediment

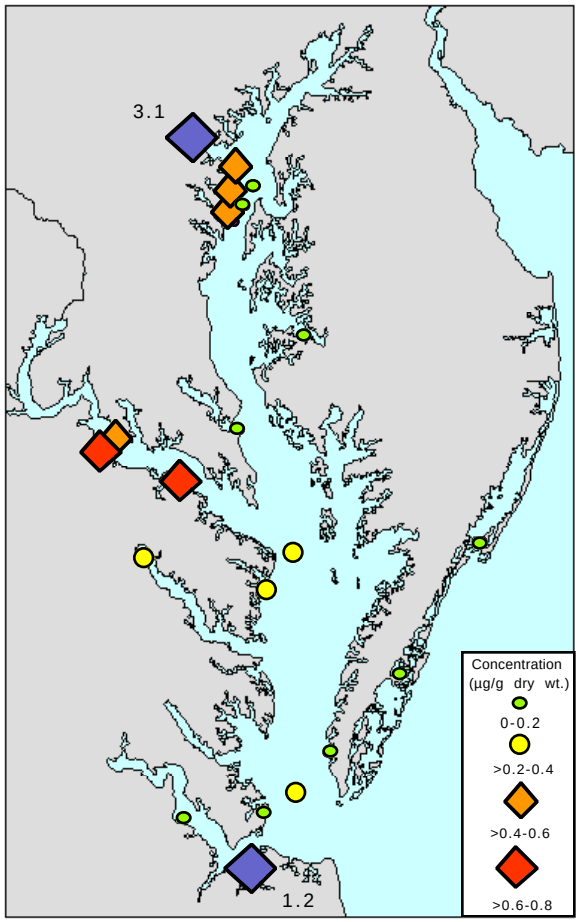


Figure I.9. Cadmium in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T nationwide 85th percentile (µg/g dry wt.).

Mercury in sediment

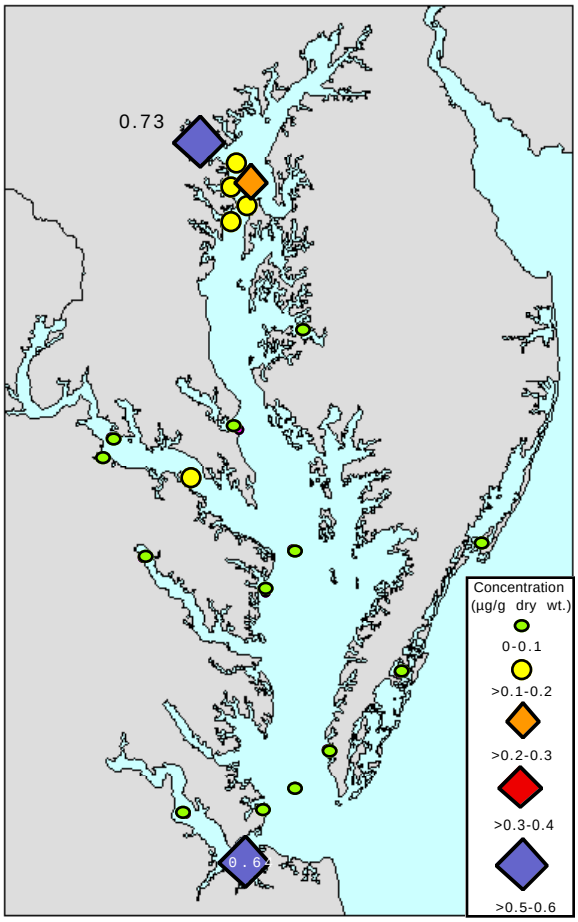


Figure I.10. Mercury in sediment. Average of data from 1986 to 1995. Concentrations were below the NS&T nationwide 85th percentile (µg/g dry wt.).

Lead in sediment

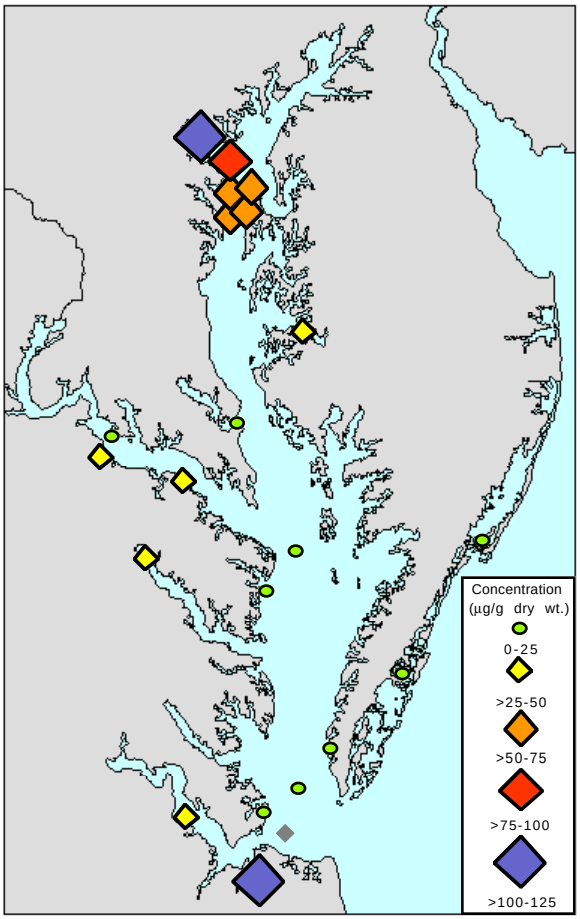


Figure I.11. Lead in sediment. Average of data from 1986 to 1995. Concentrations were below the NS&T nationwide 85th percentile level (µg/g dry wt.).

∑PAHs in sediment

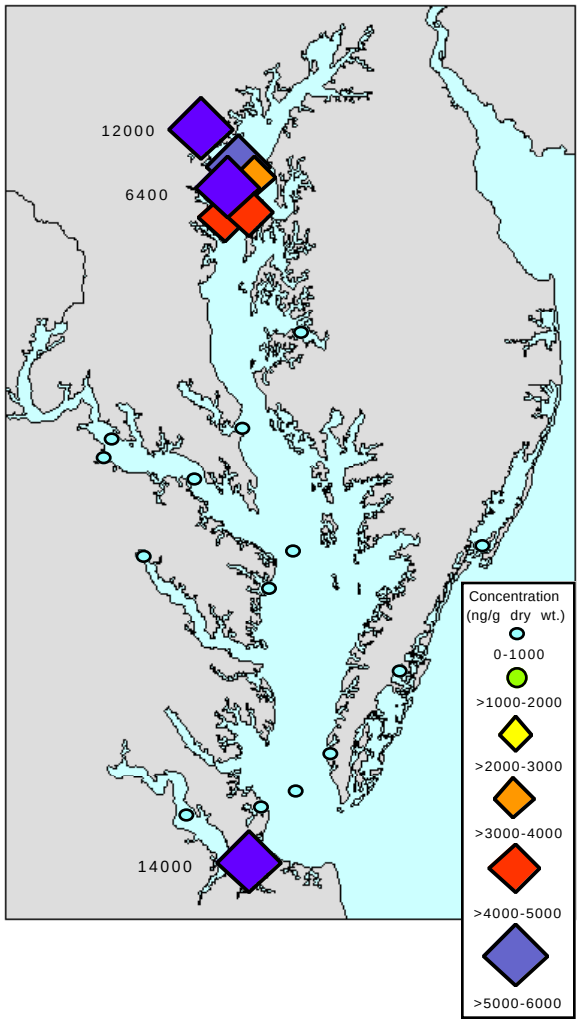


Figure I.12. Total polycyclic aromatic hydrocarbons (∑PAHs) in sediment. Average of data from 1986 to 1995. Concentrations were below the NS&T nationwide 85th percentile level (ng/g dry wt.).

∑PCBs in sediment

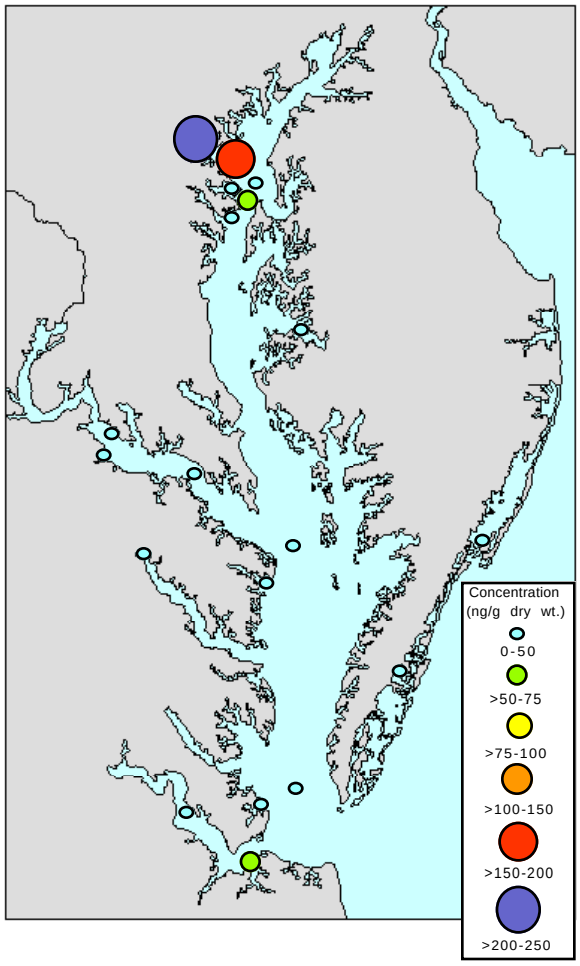


Figure I.13. Total polychlorinated biphenyls (∑PCBs) in sediment. Average of data from 1986 to 1995 (ng/g dry wt.).

∑DDTs in sediment

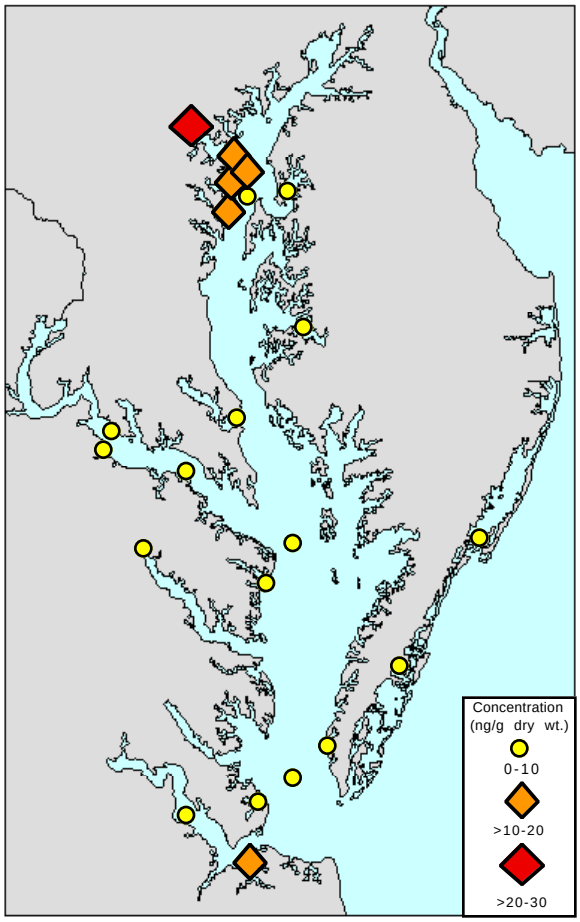


Figure I.14. Total DDT and metabolites (∑DDTs) in sediment. Average of data from 1986 to 1995. Concentrations were below the NS&T nationwide 85th percentile (ng/g dry wt.).

Total alpha-chlordane, *trans*-nonachlor, heptachlor and heptachlor epoxide in sediment

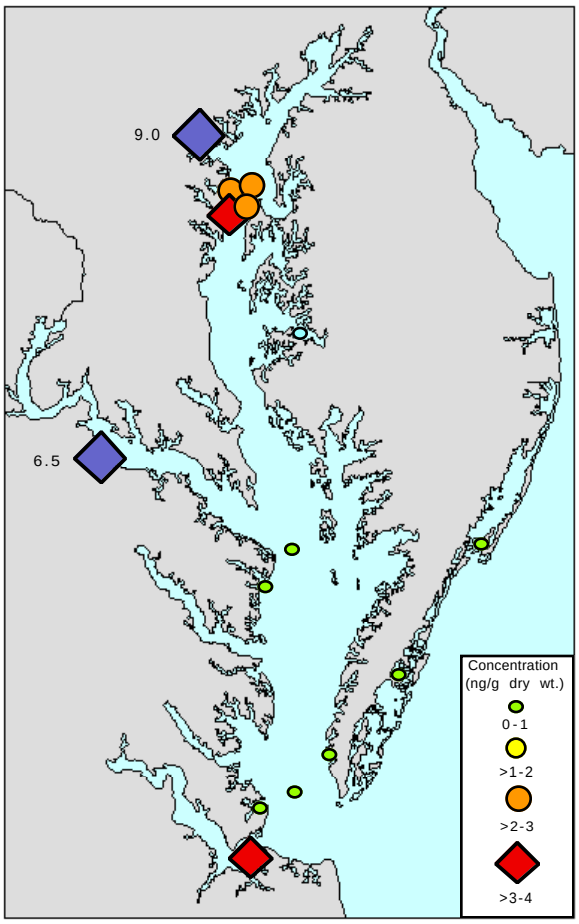


Figure I.15. Total alpha-chlordane, *trans*-nonachlor, heptachlor and heptachlor epoxide in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T nationwide 85th percentile (ng/g dry wt.).

Dieldrin + aldrin in sediment

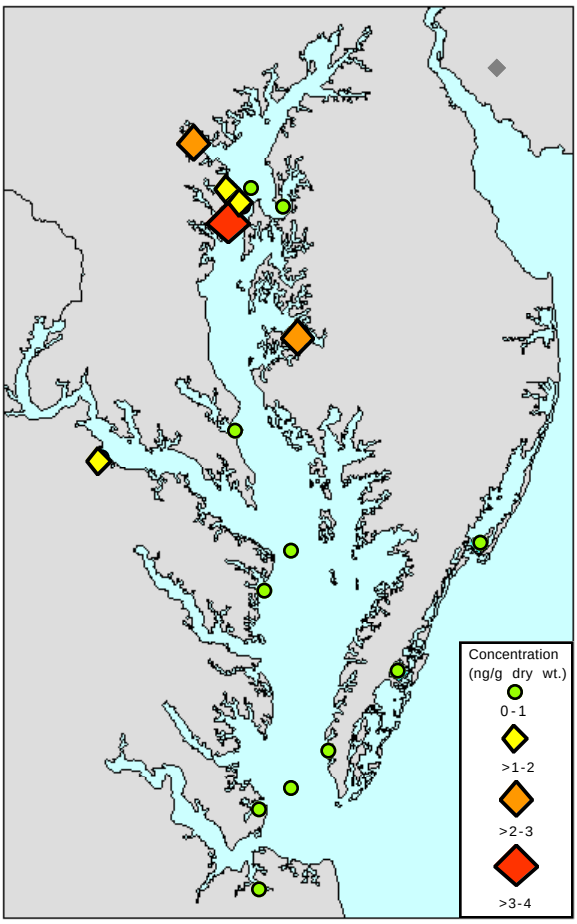


Figure I.16. Total dieldrin and aldrin in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T nationwide 85th percentile (ng/g dry wt.).

Hexachlorobenzene in sediment

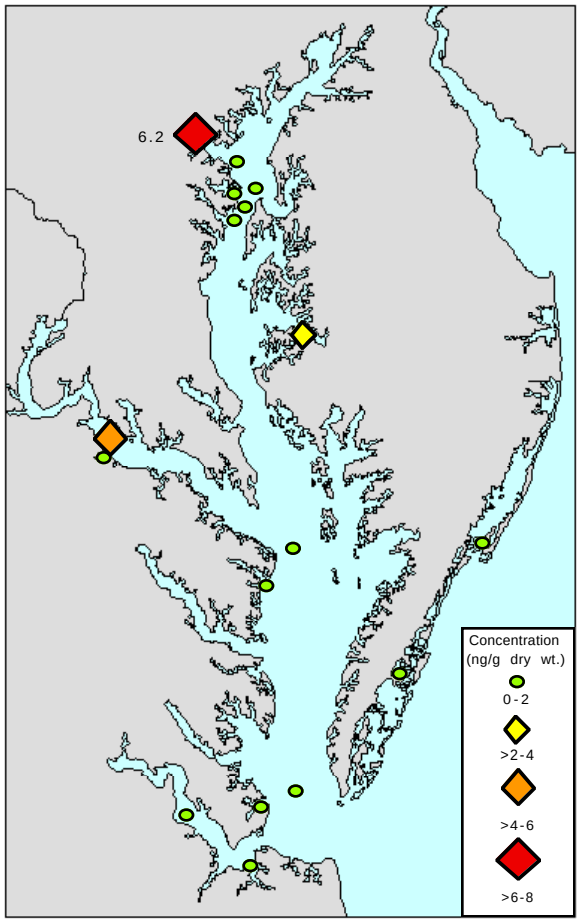


Figure I.17. Hexachlorobenzene in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T nationwide 85th percentile (ng/g dry wt.).

Lindane in sediment

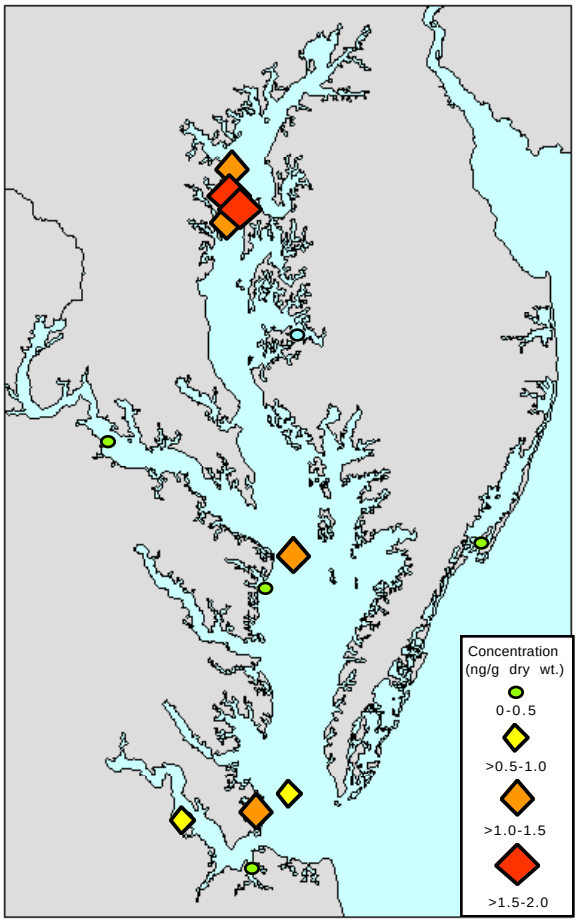


Figure I.18. Lindane in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T nationwide 85th percentile (ng/g dry wt.).

Oyster sampling.

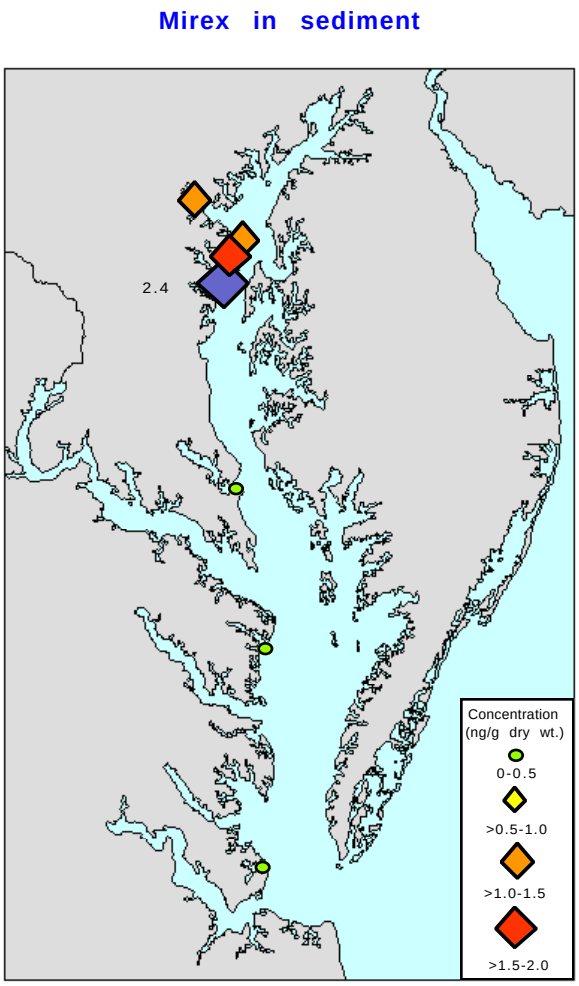


Figure I.19. Mirex in sediment. Average of data from 1986 to 1995. Concentrations noted with a diamond are above the NS&T nationwide 85th percentile (ng/g dry wt.).

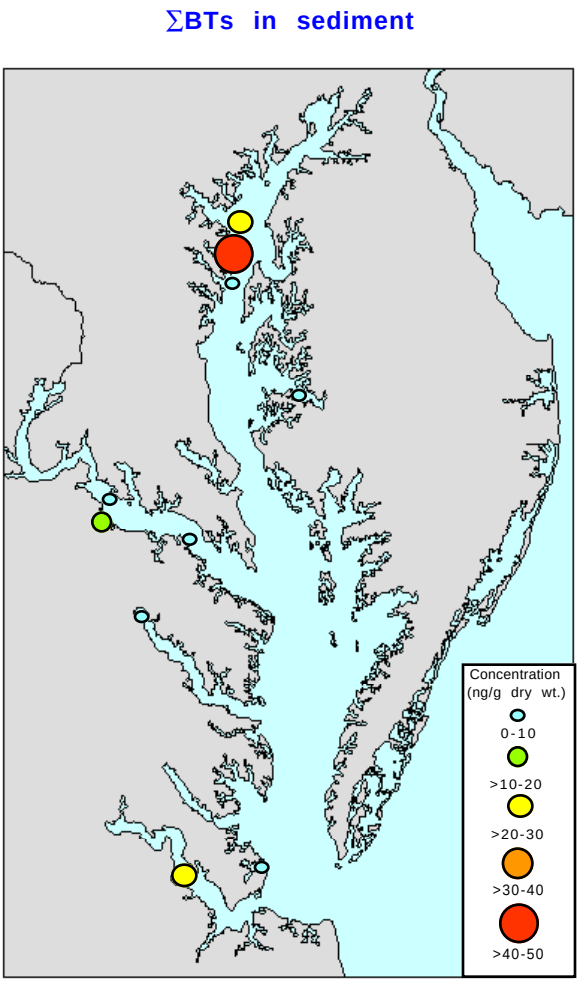
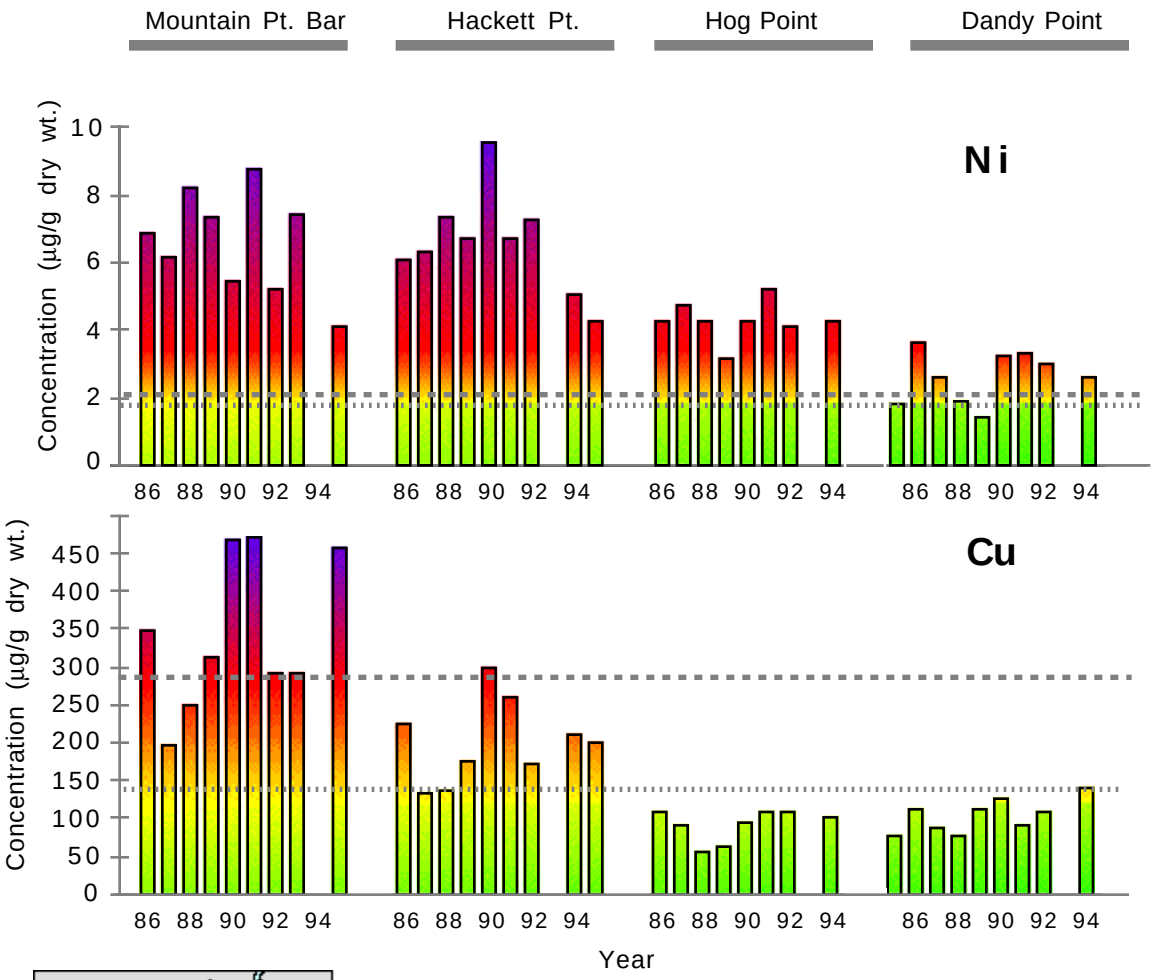


Figure I.20. Total butyltins (∑BTs) in sediment. Average of data from 1997 only (ng Sn/g dry wt.).

Appendix II

NS&T oyster trend data for Chesapeake Bay

Nickel and copper trends in oysters collected at Mountain Point Bar, Hackett Point Bay, Hog Point and Dandy Point



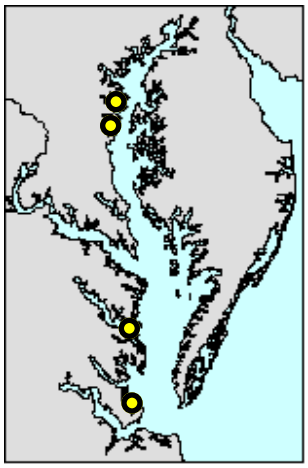


Figure II.1. Nickel and copper trends in oysters collected at Mountain Point Bar, Hackett Point Bay, Hog Point and Dandy Point. Dotted blue line is NS&T median and dashed red line is NS&T nationwide 85th percentile. (µg/g dry wt.).

Zinc and arsenic trends in oysters collected at Mountain Point Bar, Hackett Point Bay, Hog Point and Dandy Point

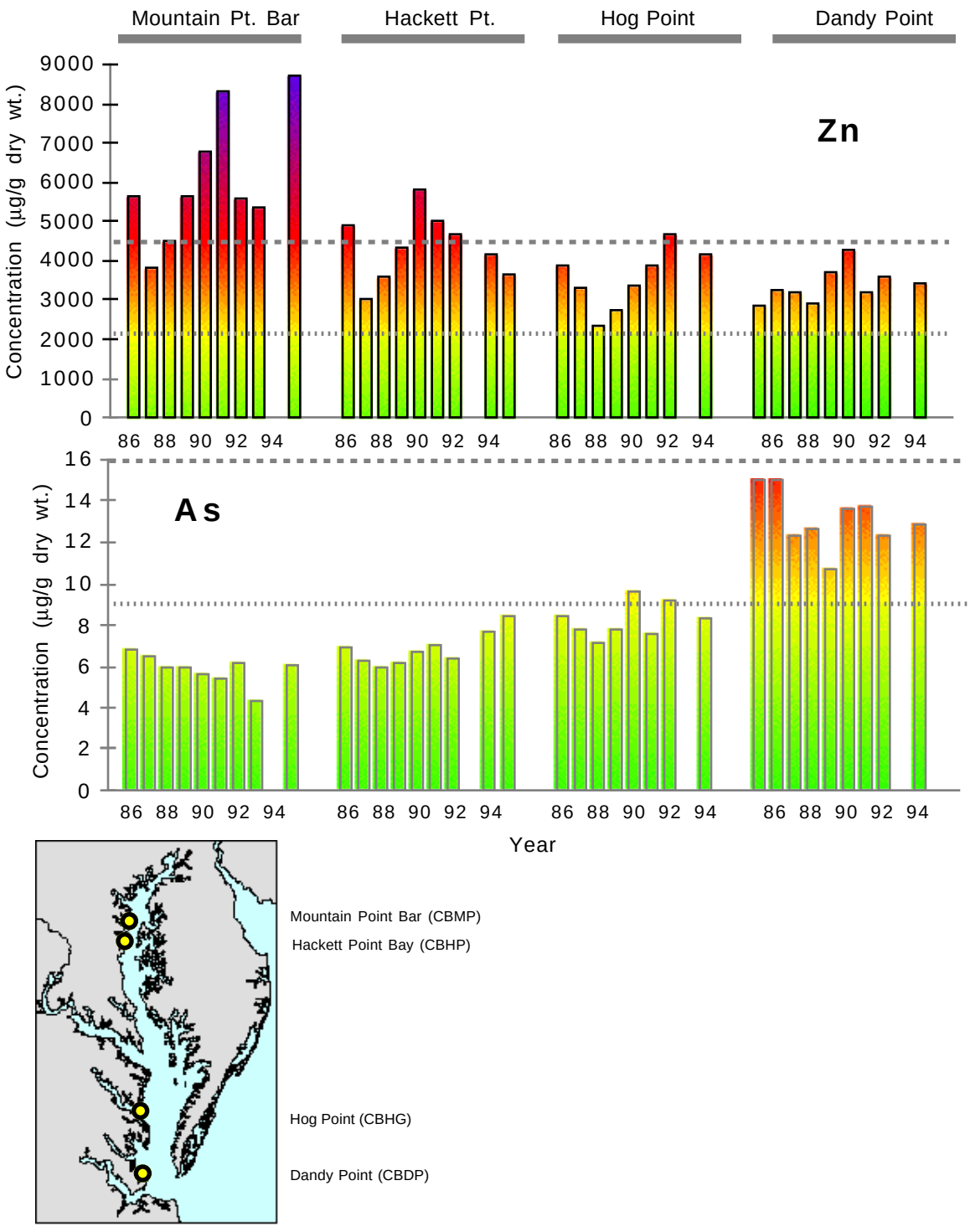
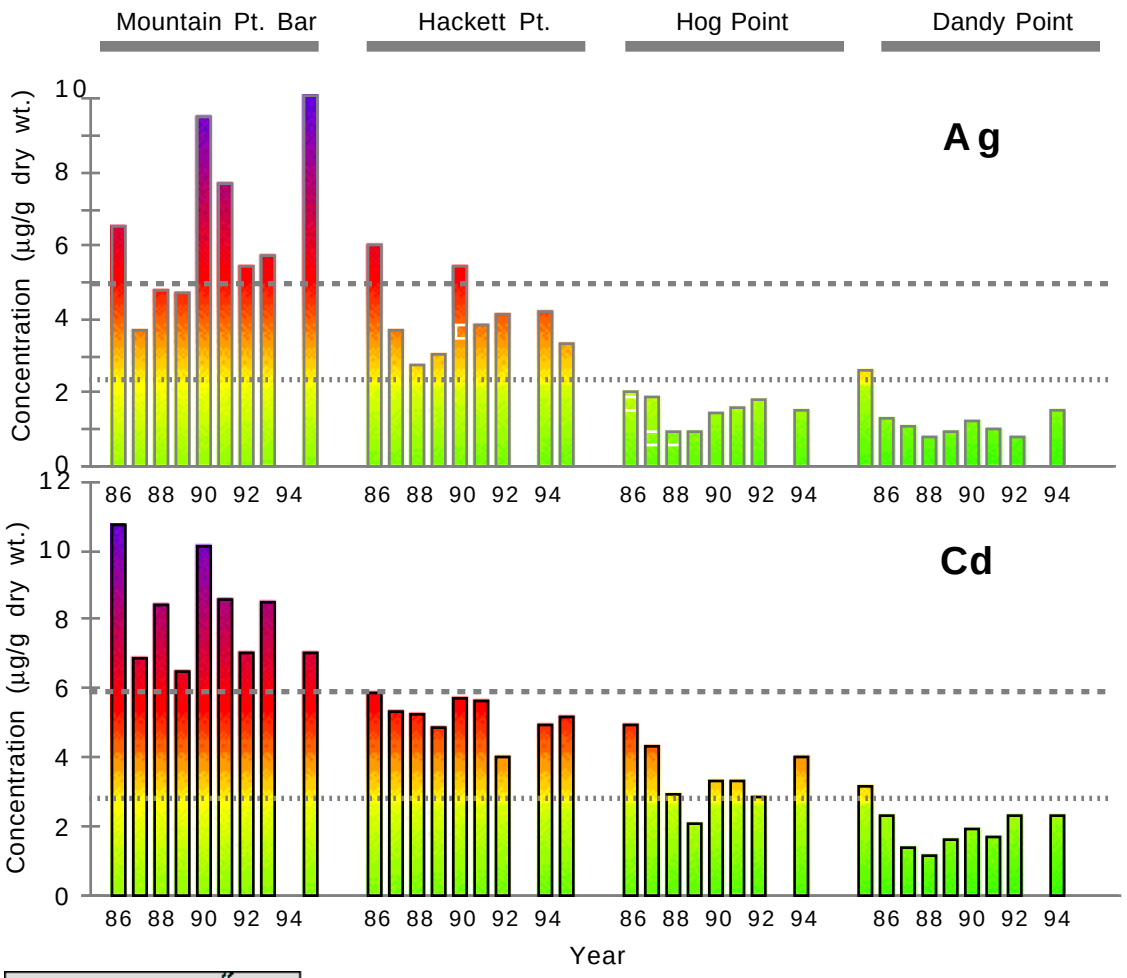


Figure II.2. Zinc and arsenic trends in oysters collected at Mountain Point Bar, Hackett Point Bay, Hog Point and Dandy Point. Dotted blue line is NS&T median and dashed red line is NS&T nationwide 85th percentile. (µg/g dry wt.).

Silver and cadmium trends in oysters collected at Mountain Point Bar, Hackett Point Bay, Hog Point and Dandy Point



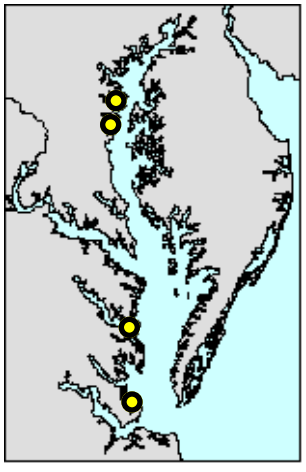
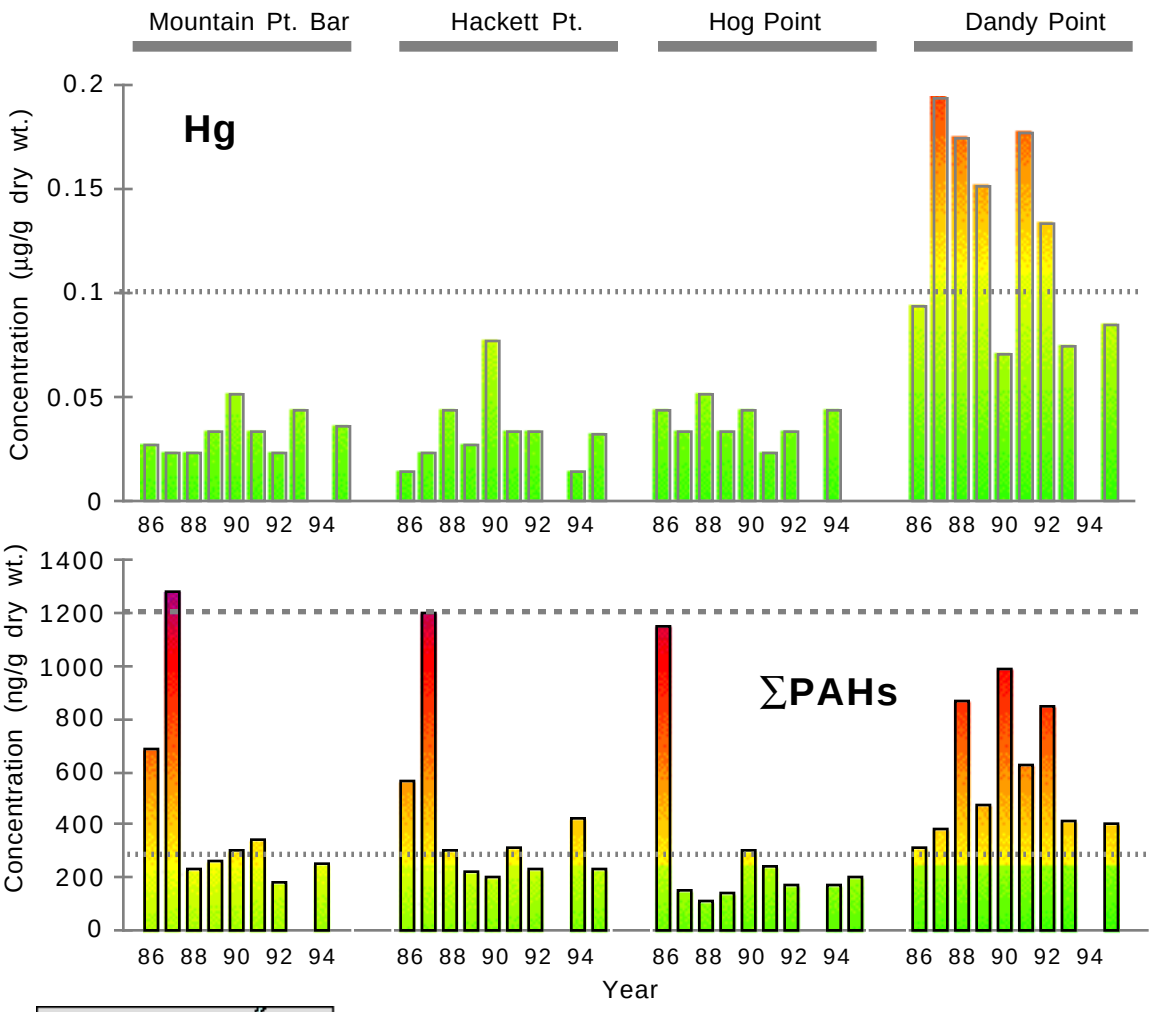


Figure II.3. Silver and cadmium trends in oysters collected at Mountain Point Bar, Hackett Point Bay, Hog Point and Dandy Point. Dotted blue line is NS&T median and dashed red line is NS&T nationwide 85th percentile. (µg/g dry wt.).

Mercury and PAHs trends in oysters collected at Mountain Point Bar, Hackett Point Bay, Hog Point and Dandy Point



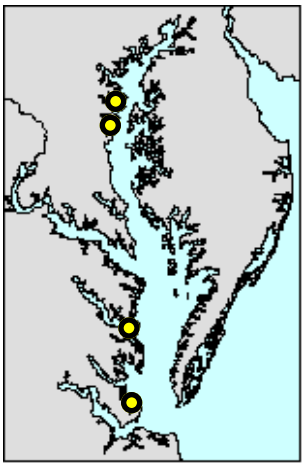


Figure II.4. Mercury (µg/g dry wt.) and PAHs (ng/g dry wt.) trends in oysters collected at Mountain Point Bar, Hackett Point Bay, Hog Point and Dandy Point. Dotted blue line is NS&T median and dashed red line is NS&T nationwide 85th percentile.

∑PCBs and DDT and metabolites trends in oysters collected at Mountain Point Bar, Hackett Point Bay, Hog Point and Dandy Point

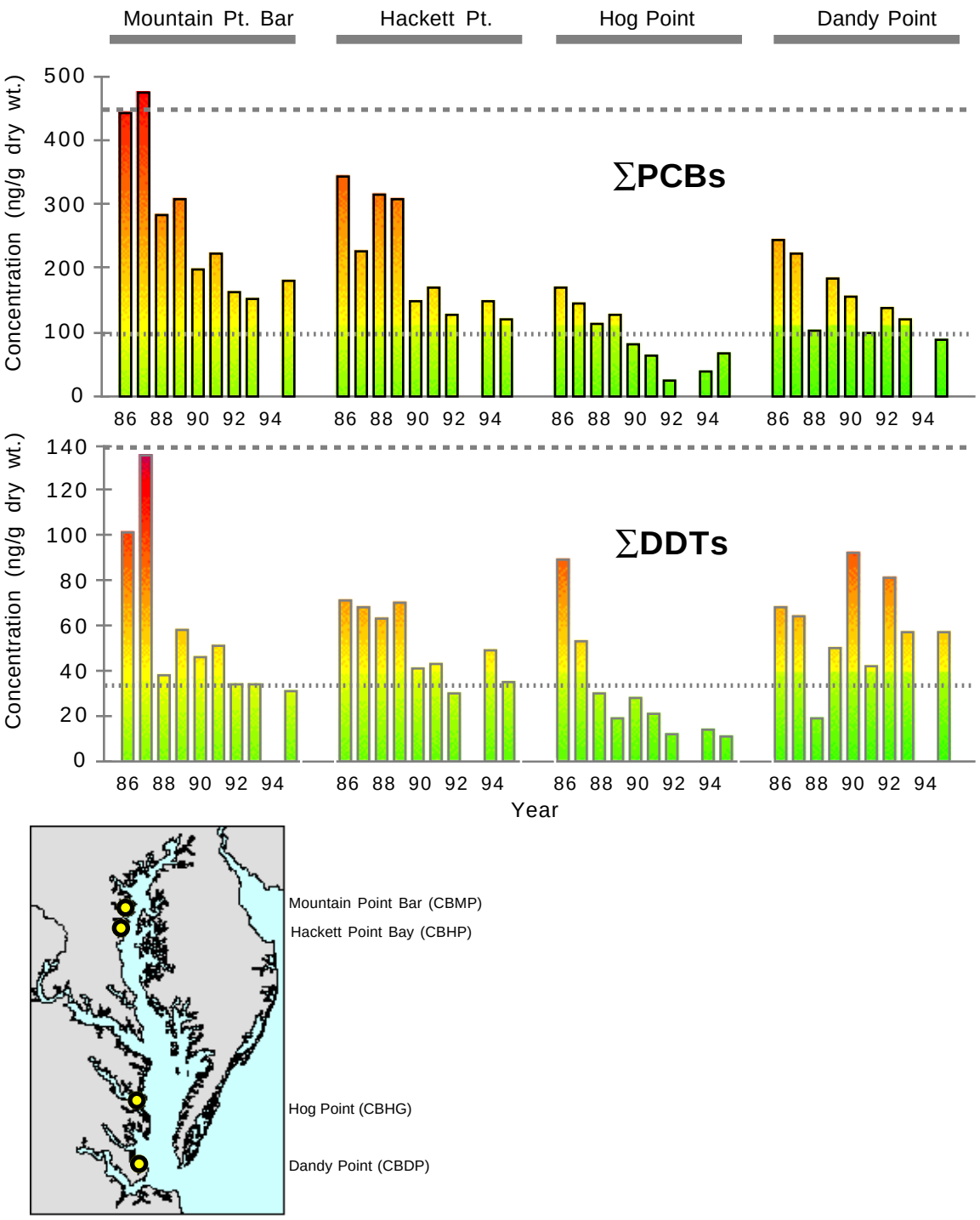


Figure II.5. ∑PCBs and DDT and metabolites trends in oysters collected at Mountain Point Bar, Hackett Point Bay, Hog Point and Dandy Point. Dotted blue line is NS&T median and dashed red line is NS&T nationwide 85th percentile (ng/g dry wt.).

Total chlordane pesticides, and dieldrin and aldrin trends in oysters collected at Mountain Point Bar, Hackett Point Bay, Hog Point and Dandy Point

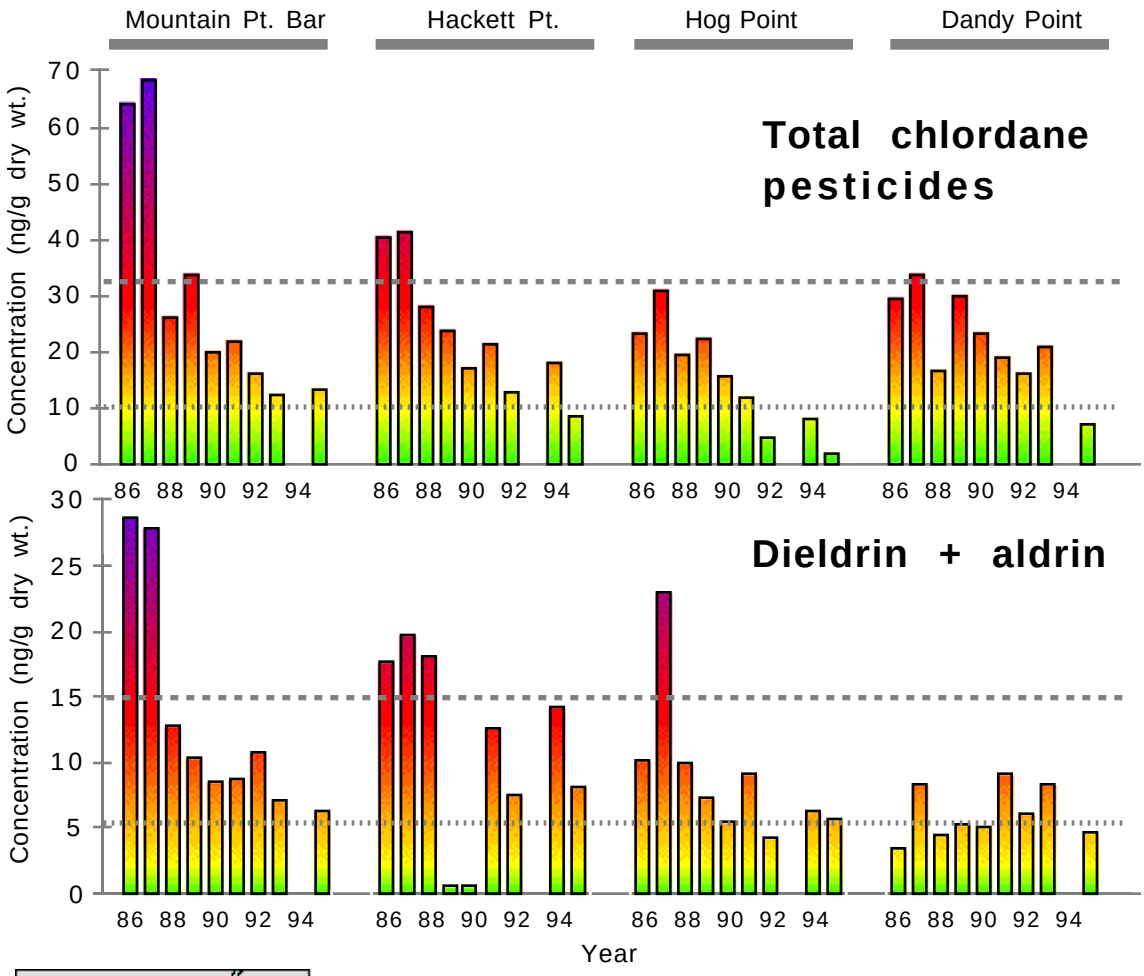


Figure II.6. Total chlordane pesticides, and dieldrin and aldrin trends in oysters collected at Mountain Point Bar, Hackett Point Bay, Hog Point and Dandy Point. Dotted blue line is NS&T median and dashed red line is NS&T nationwide 85th percentile (ng/g dry wt.).

Zinc and mercury trends in oysters collected at Dandy Point and Cape Charles

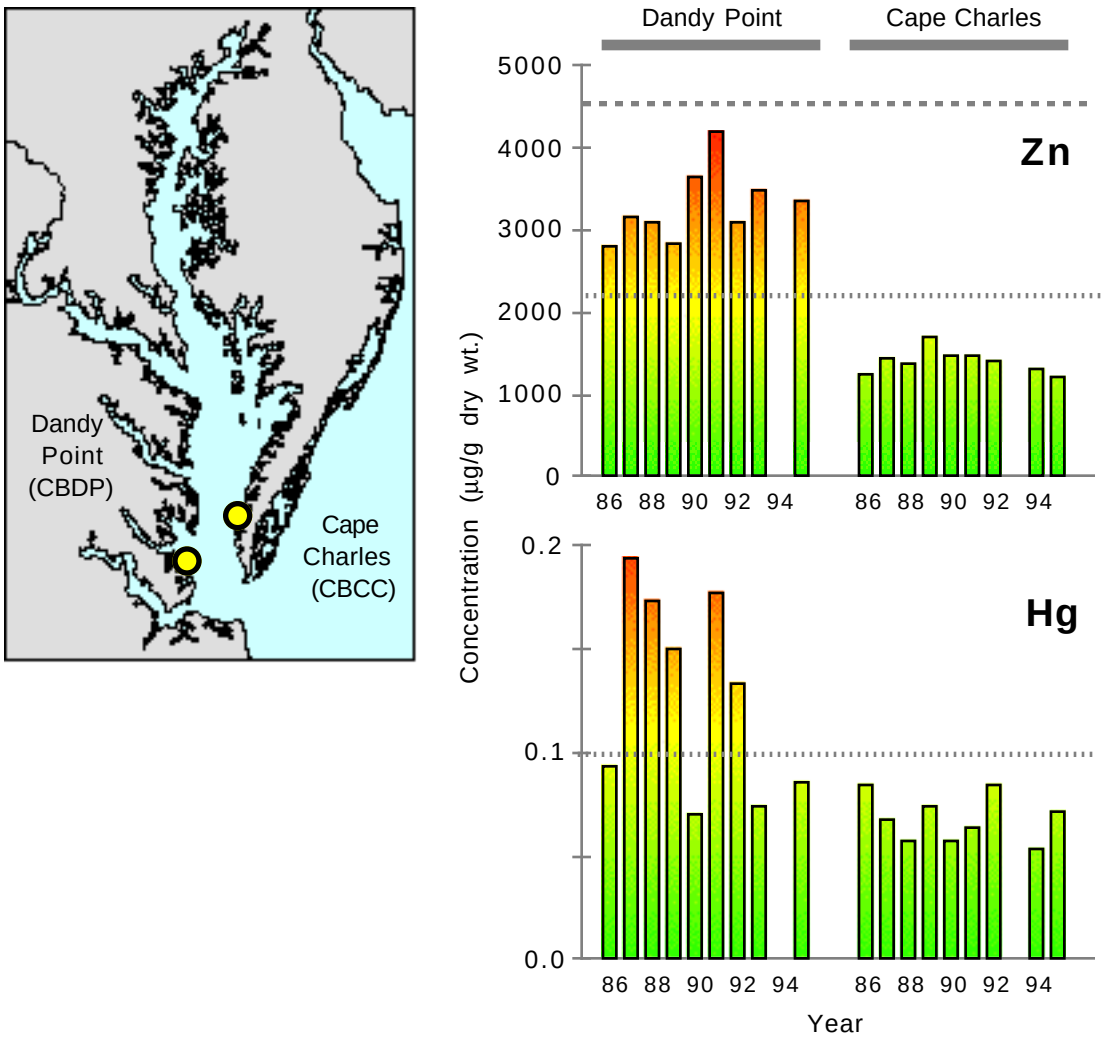


Figure II.7. Zinc and mercury trends in oysters collected at Dandy Point and Cape Charles. Dotted blue line is NS&T median and dashed red line is NS&T nationwide 85th percentile. (µg/g dry wt.).

Total PCBs and total chlordane pesticides trends in oysters collected at Dandy Point and Cape Charles

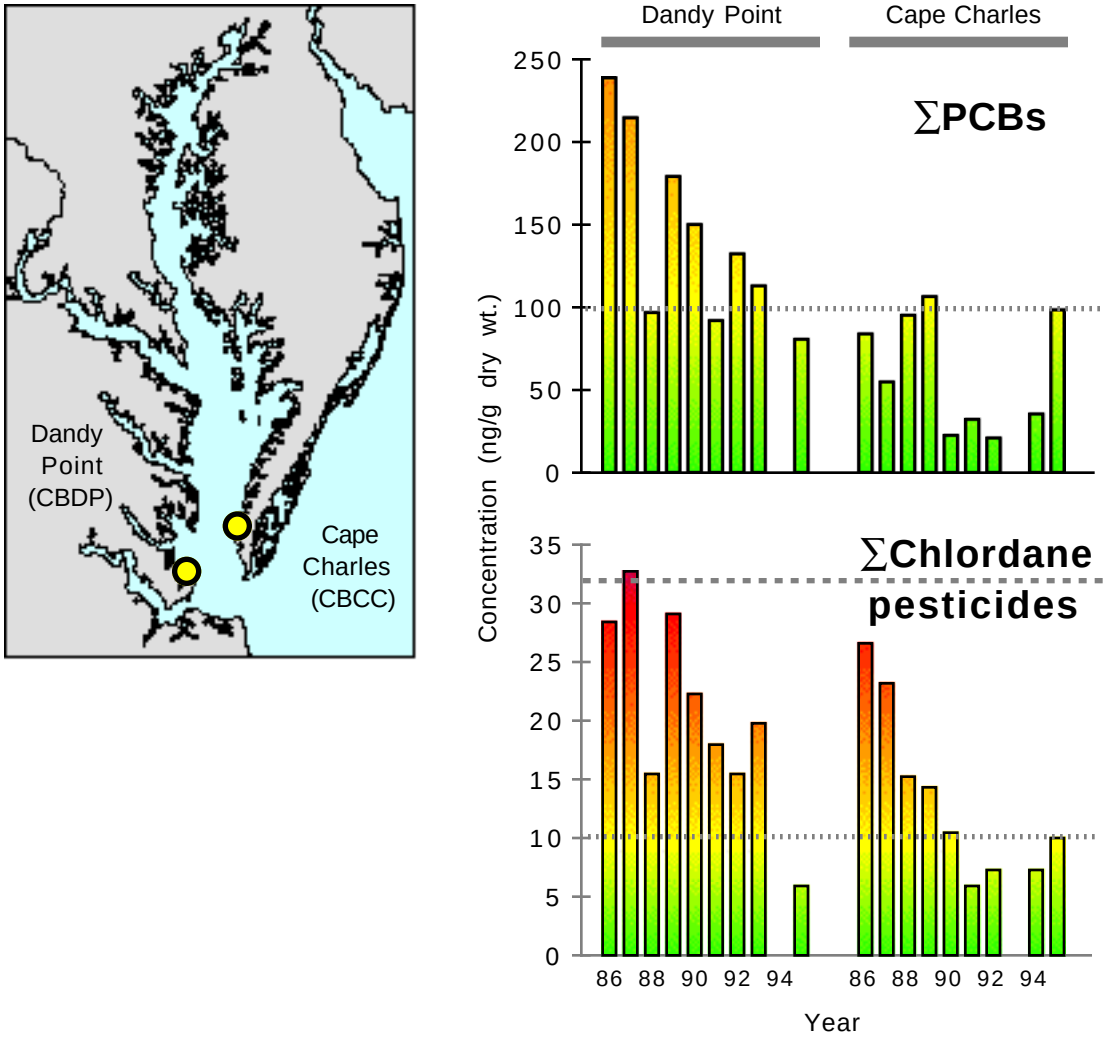


Figure II.8. Total PCBs, and total chlordane pesticides (alpha-chlordane, *trans*-nonachlor, heptachlor and heptachlor epoxide) trends in oysters collected at Dandy Point and Cape Charles. Dotted blue line is NS&T median and dashed red line is NS&T nationwide 85th percentile. (ng/g dry wt.).

Disclaimer

This report has been reviewed by the National Ocean Service of the National Oceanic and Atmospheric Administration (NOAA) and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for their use by the United States Government.